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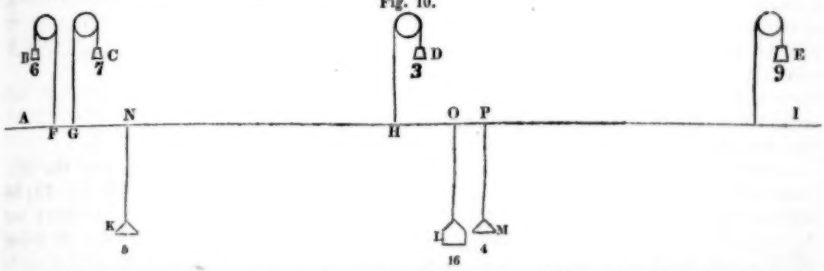
DR. LARDNER'S LECTURES.

(Continued from page 165.)

Thirdly.—When several forces are given in any parallel directions, and any others acting in a direction exactly opposite, but all parallel to each other, to find a single force productive of the same effect.

Fig. 10.



Let AI (fig. 10) represent the plane on which the following given forces, viz:—B=6, C=7, D=3, and E=9, act upwards on the points F, G, H, and I, at the several distances from the end A of 5, 6, 16, and 32 inches, and let the downward forces be K=5, L=16, and M=4, acting on the points N, O, and P, at the several distances from the same point A of 8, 18, and 20 inches. Now it is evident there are still two conditions to be observed. 1. Whether the sum of the upward be equal to that of the downward weights, which may be found by addition, for were the weights alone to be considered, they would be in equilibrium. 2. Whether the weights act in their proper places, which is to be found by the same rule as before; thus taking the upward forces.

The weight B × the dist. fm. A=6×5=30
— C . . . . . 7×6=42
— D . . . . . 3×16=48
— E . . . . . 9×32=288—408.

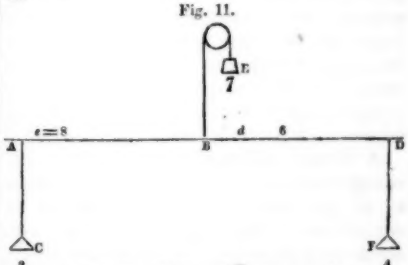
Now if the products of the downward forces be equal to the above sum, they will be in equilibrium as

The weight K × the dist. fm. A=5×8=40
— L . . . . . 16×18=288
— M . . . . . 4×20=80—408.

And since they are in equilibrium they destroy the effects of each other, and the plane will be at rest.

There is one more case to be attended to.

Fig. 11.



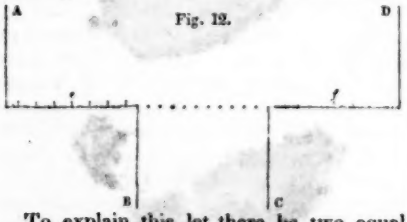
Let AD (fig. 11) represent a plane, on which act the two unequal forces or weights C and E, in opposite directions, and of which E is the greater. It is required to find the place and weight of a single force that will produce equilibrium. Now from what has been previously stated, the required force will be equal to the difference of those which are given, viz: E—C. With regard to its place, it has been shown that two forces will keep a single force in equilibrium if one force bear the same proportion to the other, as the distance between the opposite weight. Now supposing the distance between the points A and B to be ex-

pressed by the letter *e*, this proportion will stand thus: (D—C)·C::*e*: the distance between the point B and that on which the weight (E—C) acts, and which distance may be called *d*. But if the weights C and E be known, then the other parts may be also discovered, (provided the distance between them be also given.) Let the weights C=3 and E=7, then E—C=(7—3)=4, which will be the weight required, and let the distance *e*=8 inches, then the proportion will be as 4:3::8:6, which will be the value of *d*, and consequently be the distance from the point B, that the required weight, F=4, must be to keep the other weights in equilibrium.

In the last case these given forces were unequal. Now it can be proved, that the nearer they approach to equality, the further will be the distance of the required force, until they are exactly equal, when the distance will be infinite. Thus, supposing the weight C to be equal to 6, then the proportion will stand thus. As E—C:C::*e*:*d*, or as (7—6)=1:6::8:48, which would be the distance of the required weight from B; but suppose the difference to be still less, viz: A=6$\frac{9}{10}$, it will be then as (7—6$\frac{9}{10}$)=$\frac{1}{10}$:6$\frac{9}{10}$::8:552, the distance required, and which will keep on decreasing until the weights are equal, when it will be as (7—7)=0:7::8:0, or infinity, when there will be no weight required, and from which this conclusion may be drawn, that if there are two equal weights acting on the same point, and in opposite but parallel directions, they will not admit of any counterpoising weight; and this may be said to be the spirit or doctrine of statical science.

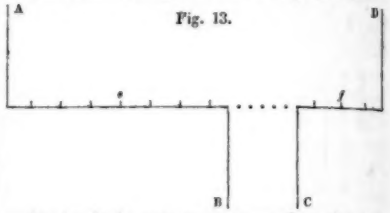
A French philosopher (Poinset) has discovered a certain property which he affirms to be the basis of the whole science of equilibrium. His doctrine is this: two equal weights acting in opposite directions, he calls a couple; and one property is, that nothing will balance a couple but a couple.

Fig. 12.



To explain this, let there be two equal forces, A and B, (fig. 12,) each equal to 16, acting in opposite, but parallel directions, at a distance of 8 inches from each other. Now it is evident that the motion so produced would be a rotative one; or in other words, it would spin round a point, supposed to be at *e*, midway between A and B. But let there be another couple of forces of the same weights, (acting at the same distance from each other,) as A and B, but in opposite directions; it is plain that they would also spin round a point, *f*, but in an opposite manner to A and B; therefore, the two couples would be in equilibrium. Consequently, it may be assigned as a rule, that if two similar couples of forces act at equal distances, and tend to produce rotation in different directions, they will be in equilibrium.

Fig. 13.

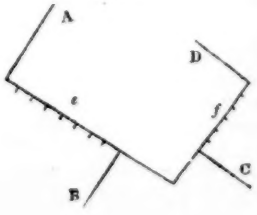


Again, it is not necessary that the distances be equal: for let A and B (fig. 13) be the same couple of forces as before; but instead of the other couple, C and D, being equal to A and B, let them be 32 lbs. each, and acting at a distance of 4 inches from each other. Now the rotative effect, which is produced by A and B, will be equal to their weight multiplied by the distance between them, or 16×8=128, and that produced by C and D, will be 32×4=128. But their effects are equal; consequently they neutralize each others effects, and are in equilibrium. Whence is deduced this rule: "If the effect produced by one couple of forces be equal to that produced by another, they will be in equilibrium."

It is beautiful to see in this rule, the wonderful harmony with which all these different combinations agree; there being still the same manner observed of multiplying the weight by the distance.

In the last cases the forces have been all considered as parallel, whereas the same rules will hold good if the parallelism be not preserved.

Fig. 14.



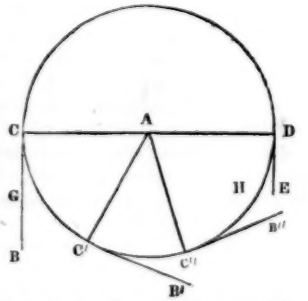
Let A and B (fig. 14) be one couple of forces of 9 lbs. weight each, acting in opposite directions, at the distance of eight inches, and let C and D be another couple acting in opposite directions, but not parallel to the former couple, and at the distance of 6 inches, with two weights of 12 lbs. each. Yet these forces will be in equilibrium, if the momentum of the couples be equal; and they are so because $9\times8=72$, and also $12\times6=72$.

Again, it is not necessary that they be on the same plane, provided the different planes are parallel to each other although this can only be shown by experiment.

In the last cases the body on which the forces acted was supposed be perfectly inflexible, but which is never the case, as no such body exists. But such is the imperfection of science, that the preceding rules must be founded on actual fictions, or on the supposition that there exists a body which has *no* existence: consequently, there is another set of rules to be learnt, and which are called corrections, which are compensations for the fictions obliged to be used in the last case.

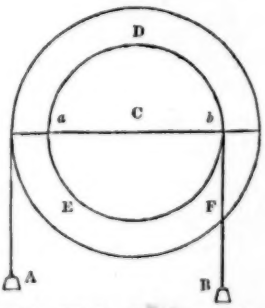
It now remains to be considered, what will be the effect produced on a solid by several forces acting together in different directions; it may be supposed to be movable on a single point, (round a centre,) or on a line, (round an axis.) When it is movable on a centre, the single force to keep it in equilibrium has been shown: therefore, it is only required to find the effect produced when movable on an axis. The most simple example of this case may be shown in a wheel.

Fig. 15.



Let A be the fixed axis (incapable of any motion) of a wheel, FGH; and let B be any weight acting on the point C, in the direction CB. Now it is evident that if the wheel be turned, the weight will then be exerted on the point C′, in the direction of C′B′; and if again turned, it will act on the point C″ in the direction of C″B″; therefore it does not signify in what directions the forces act, so long as they tend to force the wheel round the same way; consequently, its equilibrium cannot depend on the direction alone. Now suppose a weight E to be applied on the point D, in the direction of DE. If this weight E be equal to the other one B, the wheel will be in equilibrium: for the tendency which one has to produce rotation in one direction, will be counterbalanced by the other one; but if the weights be unequal, it will be in equilibrium if one weight be in inverse proportion to the other, as their distances from the centre. It has been proved that two unequal weights, when acting at distances in this proportion, will be equal in effect to a weight equal to their sum acting on this point; consequently, these weights will not produce rotation; they will only press on the axis of the wheel, and that with a force equal to the sum of the weights. The equilibrium will not, therefore, depend either on the forces or the direction *alone*; but on what does it depend? The rule is this: "Multiply each weight separately, by the distance of the points on which they act, from the centre, and if the products be equal, the wheel will be at rest."

Fig. 16.

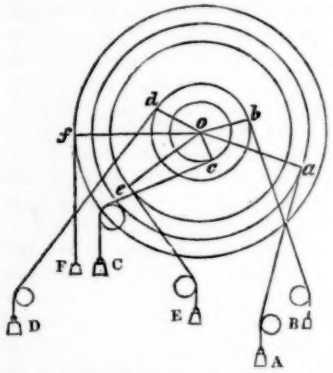


Let C (fig. 16) be the centre of a circle D, E, F, and let A and B be two unequal weights acting on points at the distances of a and b from C. Now if $Aa=Bb$, the wheel will be at rest. Let A=8 and B=12, and the distance $a=9$ and $b=6$; but $9\times8=6\times12$; therefore the wheel will be kept at rest by the unequal forces A and B.

The next case is, supposing that several forces acting in different directions tend to produce rotation in opposite ways; required the conditions of equilibrium. The rule is: "Multiply each weight by the distance from the centre of the point on which

it acts, and if the sum of the products of those forces tending to produce rotation in one way, be equal to the sum of the products of the other forces then the wheel will be at rest.

Fig. 17.



Let O (fig. 17) be the centre of a circle, G, H, I; and let A, B and C be three weights acting in one direction, and D, E, F, be three weights in another direction, and let them act at the several distances from the centre of a, b, c, d, e, and f. Then if $Aa+Bb+Cc=Dd+Ee+Ff$, the wheel will be in equilibrium. Suppose the weights to be A=3, B=6, C=8 D=5, E=4, and F=2, and the distances to be $a=7$, $b=3$, $c=2$, $d=3$, $e=6$, and $f=8$, then the several products will be,

3×7=21	and 5×3=15
6×3=18	— 4×6=24
8×2=16	— 2×8=16
55	55

which are equal; consequently the wheel is kept in equilibrium, by the unequal forces A, B, C, D, E, and F.

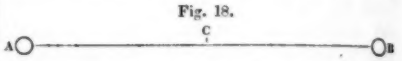
Attraction of gravitation is a particular instance of a general effect: the denomination "attraction" being the name for a class of effects, the leading feature of which is, that if two bodies are placed near each other, they will move towards each other, and along a straight line supposed to join them. The strict and philosophical meaning of attraction is not required in mechanicks: in this science the fact is only to be observed, viz: that the bodies approach each other. There *is* a cause which produces this effect, but it is not the object of this science to investigate that cause; it is sufficient for the knowledge of mechanicks that the effect *is* produced. Consequently, by "attraction" is to be understood that one body moves towards another, and by repulsion, that one body moves from, or is repelled by the other; the language of effects, and not of causation, being used.

Attraction is reduced into several classes, each having peculiar or specifick properties, as magnetick attraction, electrick attraction, &c.; all of which form the foundations of distinct sciences; but the only one now to be considered, is the attraction of gravitation, which is found to exist in every thing, whether solid, liquid, or gas.

The first thing to be considered, with regard to gravity, is its law, viz:

If two equal masses of matter be placed near each other, and no force exerted to keep them in their places, they will move towards each other, and along a straight line supposed to join them, and they will meet at a point equidistant between them. Thus let A and B be the two masses be-

Fig. 18.

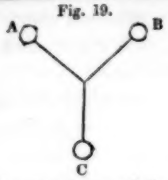


yond the influence of all other bodies; they will move along the straight line AB, and will meet at a point C, midway between the two. And this effect will ensue, whatever the quality of the masses may be. But in what proportion will these consequences ensue? The force with which the two masses are found to attract each other, *decreases* in the same proportion* as the square of the distance between them. Let the distance be equal to 1, and let the force be equal to 2. Now, if the distance be increased to 4, the force will decrease in the same proportion as (or, what is the same thing, will be in the inverse proportion to) the square of the distance between them: therefore, as $1:2::(4^2)16:\frac{1}{8}$, which will be the force of attraction. In the same manner, if the distance be 3, the force will be $=\frac{2}{9}$ if $2=\frac{1}{2}$, &c. This is the general law of gravity; and it is by this law that the planets are kept in their course round the sun. It may be asked, what is the difference between this kind of attraction and any other species? The difference is, that the former is an universal property which the others are not.

The last rule applied only to equal masses; but let us now suppose them to be unequal. Let A be one mass, and B and C be two others, each equal to A. Now they each exert the same degree of attraction as A; but if they be incorporated,

* This proportion is the same both in magnetick and electrick attraction.

Fig. 19.

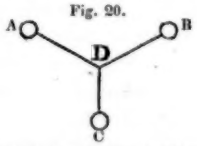


their effect is not changed, but the single mass will then possess double the attraction that is possessed by A: thus the attractive power is increased in the *same* proportion as the size

The general rule is, therefore, that the force of gravity varies *directly* as the *quantity* of the masses, and *inversely* as the square of the distance between them.

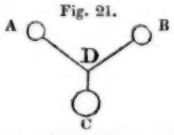
It may be asked, why is not *every* thing attracted? In fact, such is the case, but in so small a degree, as to be only perceptible to philosophical tests. To explain this,

Fig. 20.



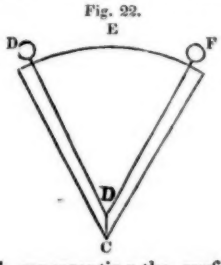
let A, B, and C, be three bodies: now, if they be equal, they will all meet in the central point D. But suppose one of these bodies, C, be larger than the others, then

Fig. 21.



the point D, at which they meet, is nearer that body than the others. Again, let DEF

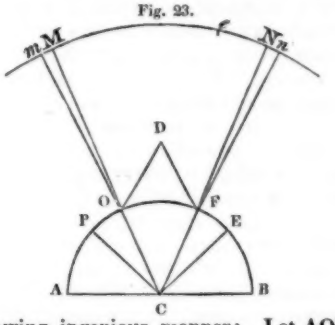
Fig. 22.



be an arch representing the surface of the earth, of which the centre of attraction is C, and let A and B be two bodies situated near the surface, it is evident that, from the point at which they will meet (D) being so near the centre C, the two bodies will have but little sensible motion towards each other.

There are some phenomena of this property which are, however, manifest. For instance, a weight being suspended near a mountain from a fixed point, was found to be attracted by the mountain, and consequently to deviate from the perpendicular. This experiment was made on a mountain called Chimborazo, and was done in the

Fig. 23.



following ingenious manner: Let AOFB represent the surface of the earth, of which C is the centre, and OF the base of a mountain ODF.* Let *e* represent the position of a star in the arch of the heavens, the place of which is accurately known by astronomical means. Lastly, let EC represent part of the equator, and P, the North Pole. The first experiment was made on the side F of the mountain, and the distance was found from the star *e* to *n:* a place at which a line continued in the direction of the string by which the weight was suspended, would reach the arch MeN. The experiment was then repeated on the other side O, and the distance found between a point *m* and the same star *e*. But these two distances, when added together, were found to be greater than an arch, MN, of the same number of degrees as the base, OF, of the mountain: the half of the surplus then gives the variation from the perpendicular, on account of the attraction of the mountain, which in the above experiment, was found to be 9 seconds.

There are some instances, however, in which the earth seems to possess properties exactly opposite to the last, viz: it seems to repel some bodies, or to drive them away from its surface. A balloon, for instance, when filled with gas is found to rise, instead of being attracted towards the earth: this ascent is precisely analagous to that of a cork in water, and is, on account of its being bulk for bulk, lighter than

* The mountain is here drawn in a much larger proportion to the earth than it really is, but it shows the effect in a greater degree.

common air, as the latter is in the same way lighter than water. The attraction in gas may be proved by weighing it, as may also that of common air.

Gravity subsists not only in every mass, but also in every particle of a body. Let there be one particle of matter imagined which is attracted in a certain degree, now a second particle would receive an action independent of the first, and they would fall together. A heavy body falls with a greater velocity than one that is lighter; for, on account of the resistance of the air, the velocity depending on the horizontal surface of the body, which may be proved thus: If a piece of metal be let drop from any place at the same time, with a feather or other light body, it is well known that the metal will reach the ground considerably sooner than the feather will; but if the experiment be made in the exhausted receiver of an air pump, they will both reach the bottom at the same time: thereby clearly proving that it is the resistance of the air which causes the bodies to descend with different velocities.

(To be continued.)

SCHOOLS.

The publick and private schools of this city and the neighboring towns have ever been the pride and boast of the community in general, and the mechanical interest comes in for its full share of credit for their support, and also, what is more praise worthy, if possible, for the intellectual qualifications found among their children for the various professions of life, acquired in the schools.

We do not intend to confine ourselves by any means to our sex alone, particularly in the latter remark. There are now at school, in this city, thirty-two hundred young ladies,* many of whom are advanced to the highest branches of education, taught in any part of the world; and who give promise of great usefulness, and of creditably adorning the most accomplished walks in society. Even where one's views are not of so elevated a character, there are instances of an education acquired, at considerable expense, by the dint of individual industry, and afterwards of obtaining an employment in a primary school in the city, or of a situation in the country; a situation where great talents are required, and where such talents are handsomely rewarded.

The credit, too, which our city and towns enjoy, in fact we say of all New-England, in distant states, must be highly flattering to a New-England man; and cases are by no means wanting, where full credit is awarded to us in this particular. We have a case now before us in a paper printed in Palmyra, New-York State, of the Ontario Female Seminary, at Canandaigua; a part of the advertisement of which we transcribe for the gratification of our readers, and for the encouragement of those young ladies who may incline when a *good offer* is made, (having first of all qualified themselves,) to emigrate to the western world, and there engage in the pleasing, and responsible office of a teacher, which with many a young lady, has been but a prelude to a station not *less pleasing*, nor *responsible*, but which may be attended with circumstances of greater independence and worldly happiness.

We now annex part of the advertisement referred to.

The vacancy which, from causes beyond the control of the Trustees, has existed for several months in one of the departments of this Institution, is now supplied, by the appointment of Miss HANNAH UPHAM, of Boston, Mass., to take the general superintendence of the Seminary, and to direct the studies, manners and conduct of the pupils.

Appreciating the importance of engaging in this department a lady of experience, of polished manners and accomplishments, and the highest literary qualifications, the Trustees have spared neither time nor expense, in effecting so desirable an object. The selection of Miss Upham, is the result of assiduous inquiries, made by one of the Board, during a tour of nearly two months, through the middle and eastern states, devoted exclusively to that purpose.

The Trustees are thus enabled to assure the patrons of this Institution, that they have engaged a principal Teacher, who has had many years experience in the first female seminaries in New-England, and is well qualified to give thorough instruction in the principles of a good practical English education as well as the ornamental and elegant branches, taught in boarding schools of the highest order.

*We do not include over 4200 females at the minor schools in our city.

BOSTON AND NEW-YORK.

It will not be thought out of place, I trust, if we now just take a glance at some of the local and other considerations, which have had a bearing upon the relative prosperity of the city and State of New-York in comparison with that of Boston and Massachusetts. At the commencement of, and throughout the memorable contest for our independence, Massachusetts was unquestionably the most powerful, wealthy, and influential State in the Union, though her territory was but a speck in comparison with several of the other States. No State sent so many troops into the field. No one kept its troops so well supplied, and no one made greater sacrifices than Massachusetts. While at the same time she furnished more than her full portion of moral and intellectual power; as well as persevering and enterprizing spirit, both in the cabinet and the field. Nor has the lustre and intrinsick value of the best characteristicks of her citizens been in any degree diminished or obscured since the revolution. Massachusetts still continues to send forth her enterprizing merchants, sailors and mechanicks into every part of the civilized and uncivilized world. Many of the most prosperous and influential citizens of every seaport in the United States are the sons Massachusetts. The same may be said of the West Indies, South America, Europe, India, and wherever else commerce can be pursued. Not an ocean, sea, bay or inlet in the commercial world, that is not whitened by Massachusetts canvass, and cheered and prospered by Massachusetts intelligence and enterprize. Not a State in the Union possesses so much shipping. Not a State in the Union comparatively so much capital. Not a State in the Union so much scientifick, mechanical, manufacturing and commercial knowledge. And yet after all these advantages, how poor a comparison as to the rise of real estate, increase of population, and internal resources, does Massachusetts bear with the state of New-York, or Boston with the city.

I know it will be said that there are natural advantages, which increase the prosperity of New-York, and natural disadvantages which retard that of Massachusetts. It is true, the deep and unobstructed waters of the Hudson, running 160 miles into the heart of the State, do present natural advantages, which, when improved, are of incalculable value.

But what did these natural advantages do for New-York, the first one hundred and fifty years after its settlement? And how were the natural disadvantages of Boston and Massachusetts, during that time overcome?

New-York was settled earlier than Boston, and from the first moment of her settlement, possessed of all those natural advantages which now attract so much attention through the Union and the world. The principal difference between these two States, before and since the revolution, is, that the science, influence and enterprize of the citizens of New-York, have been directed to the improvement of the natural advantages, which the God of nature has bestowed upon them. While those of Massachusetts have contented themselves with looking on, admiring and doubting.

It is true, New-York has an immense back country, and its prosperity has been owing to the settlement of those vast tracts of rich and fertile land in the western part of that state. But what is the settlement of these lands owing to, but the improved facilities of transporting settlers and necessaries to them on the one hand, and, on the other, their produce to a profitable market?

It is equally true, that the growth of any city, in a land of liberty, must be somewhat in proportion to the extent and richness of the country, which is to receive a supply of foreign goods from it, and in which a market is to be found for its own productions.

But it ought not to be forgotten, that Troy is as near Boston as New-York, and of course the moment a mode of conveyance is opened between Troy and Boston, through which a barrel of flour can be transported, as cheap as from Troy to New-York, that moment Boston and Massachusetts are competitors with New-York, for the whole of that immense and fertile territory, to the shores of lake Erie; and a part of Pennsylvania, Ohio, and even Michigan, may be expected to find its best outlet for surplus produce at Boston. * * * * *

The City and a Rail-Road.

* * * But whatever diversity of sentiment there may be in relation to other parts of the Commonwealth, it appears to me, there can be but one sentiment, as to the influence it will have on the pecuniary prosperity of this city. To include my belief on this point in one word, and I have now time for no more, the increased value of property, in Boston only, will be much more than sufficient to defray the whole expense of

this road. I am not without my fears that you may think this an extravagant prediction; but look a moment. The present valuation of property, according to your Assessor's books, amounts to nearly seventy millions of dollars, and if it had all been found, I have no doubt but that it would amount to more than one hundred millions. About half of this is real estate; of course a rise of 6 or 8 per cent on the real estate only, of this city, would amount to a sum nearly sufficient to construct a Rail-Road, with a double track to Albany.

But this calculation is made on the presumption that the value of property will remain the same as it now is, if no improvement of this kind should be carried into effect, when, as certain as cause and effect are connected, and as the one follows the other, there must be a diminution in your population, and, of course, in the value of your property. In truth you are realizing this diminution at this moment, and from this very source. No axiom is more certain, and no one ought to be better understood by the rulers of a country, than that capital will go where it can find the most profitable employment, and it is equally certain to a great extent, that it will carry its owners with it; at least a part will go, and that part will be those who are the most enterprizing, who are now contributing most to the prosperity of your city. So confident am I in the correctness of these positions, that I will venture one more (perhaps you will say still more extravagant) prediction, and that is, if no measure of this kind is adopted, in ten years* from this time, there will be a diminution in the value of property in this city to an amount more, much more, than sufficient to construct this road. * * *

Town and Country.

* * * Perhaps, however, some of us from the country, when at our own firesides, and thinking of no one's fireside but our own, may shrug up our shoulders, and ask, Of what consequence is it to us, whether the property of Boston increases or decreases? But it would be well for us to inquire how it happens, that, when our Legislature adopt the old maxim,—which, I cannot but think, is still a good one,—That it is better to pay for what we need, than to run in debt for it; and Boston, a little spot, that I can cover on the map with my thumb, is called upon to pay a third of it. Would country influence at this moment have been enabled to throw seven-eights of the whole expense of the Commonwealth upon this city, and raise, in the shape of bank taxes, auction taxes, &c. two or three hundred thousand dollars annually, from the sources and fruits of its prosperity, if Portsmouth, or Providence, or New-York had been the commercial capital of New-England? What has raised up a city in Lowell, and brought a market and all the advantages of commercial enterprize and prosperity into the vicinity, of one hundred square miles, increasing the value of the whole, and of some of it more than forty fold? What has done the same thing in Waltham, Ware, Springfield, and, to a greater or less degree, in a hundred other places in the Commonwealth? I answer, Boston capital, Boston prosperity. As well might the foot say to the head, I have no need of thee; or the head to the foot, I have no need of thee; as the country to say to the city, I have no need of thee. Our dependence upon each other is mutual; we must rise or fall, live or languish, sink or swim, together; and God forbid that we should ever become so unmindful of what we owe to each other, or so regardless of our mutual and best interests, as to refuse to pull together.—But it may be said, perhaps, that surplus capital would come from other States to improve the natural advantages and facilities of our own. So it would, after there was no further opportunity for it at home, and not till then. Nor then, unless the preponderance in favor of removal is quite manifest; for there is something in the bosoms of most men that prepossesses them in favor of home; and there are few, very few, who do not prefer devoting their influence and property to the promotion of the prosperity of their own State, their own town, or neighborhood, to that of another. And when I consider the high moral and religious character which has been sustained by the inhabitants of Massachusetts from its first settlement; when I consider the weight of influence which she has uniformly given to the promotion of the independence and prosperity of our common country; when I consider her whole moral and political career, from first to last; I do not wonder that this feeling predominates in the hearts of all. I rejoice in the fact of its existence, and look to it as that bond of union, which is to carry the whole State forward together in the accomplishment of this, and many other similar enterprizes.—(Jackson's Lectures.)

* It is believed by many, that without waiting ten years, the event here predicted is already realized.

COMMUNICATION.] [FOR THE MAGAZINE.

DIVIDING PLATE FOR A LATHE.

SIR,—I have found a dividing plate on the pulley of a lathe, a very useful appendage. To divide one accurately is rather a difficult task. Having, after several fruitless attempts, hit upon a plan which I consider very practicable, and at the same time accurate, if done with care, I have thought it of sufficient importance to lay before your readers.

Having prepared a plate of brass the size of the pulley, namely $8\frac{1}{2}$ inches external diameter, 2 inches wide, $4\frac{1}{2}$ inches internal diameter, $\frac{1}{8}$th of an inch thick, with a projecting circular rib at the back of the plate to strengthen it; this is fastened on a cast iron pulley with small brass rivets. It requires great care to make a wood pulley that will remain true.

Sometimes the holes in the concentrick circles are drilled on the plain face of the brass plate; others have slight grooves turned where the holes are to be. I turned 11 grooves in my plate; and after dividing them and finding several intermediate numbers wanting, I drilled 10 other circles on the plain face between the grooves, so that I have 21 circles divided in the space of 2 inches in breadth, and are much less confused than they would have been had they been all in grooves, or all on the plain face. The method of dividing is as follows:—Prepare a punch with several points, (the one I used had 7 points, 1-12th of an inch apart,) cut by holding it against a steel screw running in the lathe, the same way that screw tools or chasers are made; after rounding these points with a file, the punch must be tempered; then prepare a piece of sheet brass long enough to receive as many holes as you want in the largest circle; it may be from half an inch to 1 inch wide, and about 1-32nd of an inch thick; it should be straight and smooth; draw a line in the middle of the plate, from end to end; then with your punch commence at one end; strike the blow in such a manner that the first point may make the deepest impression; then shift the punch one hole only, pressing the punch firmly into the six impressions made by the first blow; proceed in this way one hole at a time, and you will not be able to detect any error with the compasses. The holes may be finished with a small drill. The next step is to form this plate into a ring, and join the ends; this may be done by cutting a notch at one end of the plate 1-4th of an inch wide and half an inch long, leaving a narrow strip on each side, with two holes in each strip for rivets; these strips should be set outwards the thickness of the plate, to allow both ends to butt together, and the ring to be smooth inside; the end of the plate between the two strips should be filed so as to leave half a hole; the tenth hole from that should be marked; proceed in this way, marking every tenth hole, to the end; count off as many holes as you want, reckoning the two half holes at the ends as one. In cutting off the end it is best to leave rather more than half a hole, and when the ends are brought together, the hole may be adjusted by filing. If a darning needle will fit this hole, as well as any other, there cannot be much mistake; the ends may be held by a hand vice until some of the rivets are put in.

Having obtained a circle divided accurately, the next step is to transfer it to the dividing plate, which we will suppose already on the lathe pulley; let an arbor, one foot long and half an inch square, be put into the lathe; if the mandril has a square hole, so much the better; if not, a chuck with a square hole, screwed on tight, will do, as the arbor must not be allowed any side movement; on the end of the arbor, next the sliding head, a piece of seasoned wood must be put on secure, and turned to receive the ring, this may be kept from shifting by two or three small tacks, from the lathe-bed a piece of steel, rather springy, should extend up as high as the centre of the lathe, terminating in a point bent at a right angle so as to fall into the holes in the ring, and hold it fast while the dividing plate is being drilled; the drilling apparatus consists of a small drill with its arbor all of one piece of steel, (for if the drill gets loose it makes bad work,) on the arbor is a small pulley which is worked with a cane drill-bow in the left hand, the drill is put into a small frame which fits into the hole in the rest, and may be moved sideways, or up and down at pleasure, the drill is urged forward by a screw with the right hand, and thrown back by a spiral spring on the arbor between the pulley and frame next the drill. A radius line shoud be drawn across the dividing plate, so that the first hole of every circle may coincide. After the first circle is finished the ring must be unrivetted and as many holes cut off as will reduce it to the next number wanted. It will, sometimes, be better to finish some of the smaller circles before the ring is much

reduced, this may be done by skipping one or more holes.

The following are the numbers on my dividing plate, those with this * mark are in the grooves, the others on the plain face.

Cir.	No.	Subdivisions.
1	24*	12, 8, 6, ×4, 3, 2.
2	73.	
3	365*	73, × 5.
4	36,	18, 12, 9, 6, × 6, 4, 3, 2,
5	360*	180, 120, 90, 72, 60, 45, 40, 36, 30, 24, 20, × 18, 15, 12, 10, 9, 8, 6, 5, 4, 3, 2.
6	30,	15, 10, 6, × 5, 3, 2.
7	300*	150, 100, 75, 60, 50, 30, 25, 20, ×15, 12, 10, 6, 5, 4, 3, 2.
8	86,	43, × 2.
9	276*	138, 92, 69, 46, 23, × 12, 6, 4, 3, 2.
10	82,	41, × 2.
11	132*	66, 44, 33, 22, 12, × 11, 6, 4, 3, 2.
12	74,	37, × 2.
13	96*	48, 32, 24, 16, 12, × 8, 6, 4, 3, 2.
14	70,	35, 14, 10, × 7, 5, 2.
15	84*	42, 28, 21, 14, 12, × 7, 6, 4, 3, 2.
16	62,	31, × 2.
17	78*	39, 26, 13, × 6, 3, 2.
18	58,	29, × 2.
19	76*	38, 19, × 4, 2.
20	54,	27, 18, 9, × 6, 3, 2.
21	68*	34, 17, × 4, 2.

A list of numbers that may be obtained from this plate, showing in which circle they occur.

No.	Circles.	No.	Circles.	No.	Cir.	No.	Cir.
2	1	21	15	40	5	74	12
3	1	22	11	41	10	75	7
4	1	23	9	42	15	76	19
5	3,5,6,7	24	1,5,13	43	8	78	17
6	1,4,5,6,7	25	7	44	11	82	10
7	14,15	26	17	45	5	84	15
8	1,5,13	27	20	46	9	86	8
9	4,5,20	28	15	48	13	90	5
10	5,6,7,14	29	18	50	7	92	9
11	11	30	5,6,7	54	20	96	13
12	1,4,5,7	31	16	58	18	100	7
13	17	32	13	60	5,7	120	5
14	14,15	33	11	62	16	132	11
15	5,6,7	34	21	66	11	138	9
16	13	35	14	68	21	150	7
17	21	36	4,5	69	9	180	5
18	4,5,20	37	12	70	14	276	9
19	19	38	19	72	5	300	7
20	5,7	39	17	73	2,3	360	5
						365	3

T. C.

On the Manufacturing of Indigo in this Country; by William Partridge.

The value of the indigo consumed in this country, for the year 1829, cannot be estimated at less than two millions of dollars.

Of the quantity consumed, there was made in the United States about two hundred thousand pounds, or one tenth part of the consumption.

As the consumption is rapidly increasing, from the increase of population, from the extension of manufactures already established, and from the introduction of new articles of manufacture, I consider it an object of national importance, that it should be better made, and more extensively cultivated in this country.

I have been acquainted with the indigo market for more than thirty years, and never remember it in so depressed a state as it has been for the last twelve months. The average price of the sales for the last year cannot have been much over one dollar per pound. The average price of the imported has been about one dollar and fifteen cents, and of that made in this country about fifty cents. To endeavor to give such instruction to the planters, as will enable them to make an article fully equal to the imported, is the object of this communication.

The quantity of indigo made from an acre of the plant has been differently estimated by almost every maker from whom I have obtained information. Gen. Wade Hampton, who many years since made the article in South Carolina, informed me that he obtained sixteen pounds of fine indigo from the plant taken from a half acre, or thirty two pounds per acre. Other estimates make the quantity much larger, some nearly two hundred pounds to the acre. Taking the average of the different estimates, it would be at least fifty pounds. It will appear by this estimate, that it would require forty thousand acres of land to raise a supply for the present consumption; and as the demand is rapidly increasing, it is more than probable, that in ten years, it will require the product of eighty thousand acres to raise a supply for home consumption.

There are four points to be attended to in the making of indigo, which require much judgment, aided by practical skill. These are, the time of cutting the plant, the degree of fermentation to be given in the steeper, the degree of oxidizement of the coloring feculæ, and the extrication of foreign matter from the pulp after the indigo is made. Three of these processes being

purely chymical, it is not therefore, surprizing, that ordinary workmen should frequently fail in producing a good article. There is probably more loss sustained by our planters, from the ignorance of the operators, than the whole value of the article now sold.

The plant should be cut when at maturity, as it will then afford a fine color; but if cut too late, a portion of the color is then lost, and an indigo of worse quality is obtained. Mr. Dalrymple informed me, that the plant should be cut when in full flower, after the weather for some days has been dry.

Another celebrated maker of indigo, asserts, "that if the plants are suffered to stand till they run into flower, the leaves become too dry and hard, and the indigo obtained from them proves less in quantity and less beautiful—the due point of maturity is known by the leaves beginning to grow less supple, or more brittle.

It appears, that the makers of indigo differ as to the time of gathering the plant. It is greatly to the interest of our planters that they should ascertain, by direct experiment, the proper time of gathering the plant.

When the plant is gathered, it has to undergo a process by immersion in water, for the purpose of extracting its coloring matter. This operation is performed in two ways—by fermenting the green plant in a steeper, or by first drying the leaves and then simmering them in a boiler. The latter process is now pursued by some of the best makers in Bengal, and has apparently an advantage over the old process.

When the green plant is fermented in a steeper, and the process is carried a little too far, the coloring matter will become dark, and is said to be burnt—if carried a slight degree farther it will be black, and of course the indigo will be very much injured. Nine tenths of the indigo made in the United States partakes more or less of this character, and has evidently been injured by an excessive fermentation. To observe a due degree of fermentation in the steeper is the most difficult point in the whole process of making indigo; for should not the fermentation be carried far enough, a considerable loss of coloring matter will be the result. It is necessary, therefore, to carry it on to a certain point, and to draw it off the instant it arrives at that point; and this can be known only by a skilful observer who has obtained his knowledge by practice.

There is no chymical operation so difficult to describe as that of fermentation, and I almost despair of making myself clearly understood by practical workmen in the following description of the steeping process.

Fermentation has been divided by chymists into four kinds, the panary, vinous, acetick and putrefactive. The kind of fermentation given in the indigo steeper is evidently of that kind called panary, or the first stage of fermentation. It is known to be the panary by the large quantity of carbonick gas given out, which rising to the surface, floats on the top, covered with a thin pellicle of the liquid. The difficult point for the operator to distinguish is when it arrives at that degree of fermentation, and begins to assume the acetick. The same difficulty occurs with the woollen blue dyer, and the losses so frequently complained of, by the vats being out of order, and often irrevocably lost, arise from the fermentation being permitted to proceed too far.

The following directions are given as a guide for those who may be engaged in the making of indigo. Whilst the plant is in steep, draw off a little of the water, and with a pen dipped in it make a few strokes on white paper. The first will probably be high colored, in which case the indigo is not sufficiently fermented. This operation is to be repeated every quarter of an hour, until it loses its color, when it will have arrived at its true point of fermentation.

Let a small hole be made in the stopper, six or eight inches from the bottom, exclusive of the opening or aperture, for drawing off the impregnated water. Let this hole be stopped with a plug, yet not so firmly but that a small stream may be permitted to ooze through it. After the plants have been steeped some hours, the fluid oozing out, will appear beautifully green, and at the lower edge of the cistern, from whence it drops into the battery, it will turn of a copperish color. This copperish hue as the fermentation continues, will gradually ascend upwards to the plug, and when that circumstance is perceived, it is proper to stop the fermentation.

During the progress of this part of the business, particular attention should be paid to the smell of the liquor which weeps from the aperture, for should it discover any sourness, it will be necessary to let the fermenting liquor run immediately into the battery, and lime water of sufficient strength must be added, until it has lost its sourness. As it is running off it will appear green, mixed

with a bright yellow or straw color, but in the battery it will be of a beautiful green.

Another maker has given the following description of the fermenting process:

When the plant is gathered, a large quantity is put into a vat, and some wood laid above to prevent its rising above the water. The mass begins to ferment sooner or later, according to the warmth of the weather, and the maturity of the plant—sometimes in six or eight hours, and sometimes in not less than twenty. The liquor grows hot, throws up a plentiful froth, thickens by degrees, and acquires a blue color inclining to a violet—at this time, without touching the herb, the liquor impregnated with the tincture is let out, by cocks in the bottom, into another vat placed for that purpose, so as to be commanded by the first.

The boiling process, for extracting the color from the dry plant, was obtained from Mr. Dalrymple, who had for many years been an extensive indigo maker in Bengal. He says: "take an iron, brass, or copper boiler, fill it within three inches of the top with the plants, press down with stones, and cover the plants with water. The liquor must be heated, not until it boils, but until it begins to blubber, or simmer. The water, by this time, will look greenish, then draw it off into a shallow vessel or vat, and beat for one or two hours to incorporate oxygen with it. On taking some of the liquor in a white saucer, little particles will appear in it as big as a pins head and smaller, then stop beating and throw in a little lime water, upon which the indigo will precipitate to the bottom, and the supernatant water will look like brandy. The water has now to be drained off to a level with the top of the sediment, lay the sediment on a cloth to drain, and, when stiff enough, put it into moulds to dry."

The directions given by Mr. Dalrymple are evidently imperfect, for none are given for the fermentative process, and those who are in the least acquainted with the manufacture of indigo, must know, that the coloring matter cannot be developed unless the liquor has previously undergone a due degree of fermentation.

I have been recently informed, that many first rate makers of indigo in Bengal condemn the process of obtaining it from the dried leaves, on the plea that the article obtained is no better, and is much less in quantity. If any of our planters should be disposed to try the dry process, it will be necessary to inform them, that should the leaves, between gathering and drying, be subject to fermentation, only a small portion of coloring matter will be obtained, and that the loss sustained will be as the degree of fermentation.

During the precipitation of the coloring feculæ the coarsest particles, possessing the greatest specifick gravity, subside first, constituting the lower strata of the pulp, and the lighter and finer particles subsiding the last, form the upper part. It is necessary that indigo makers should take advantage of this circumstance, by first taking off the upper layer, and moulding it by itself, and the lower part by itself. By this means they may obtain several qualities of indigo from one mass of pulp.

It appears from analysis made by Bergman, Quatremere, and other chymists, that indigo of good quality does not contain more than from 46 to 47 per cent of coloring matter, and that the very best samples do not contain more than 48 per cent.

The following table will exhibit an analysis of indigo of a good quality, and of the menstruua in which the impurities are soluble.

Mucilaginous parts separable by water,	12
Resinous parts soluble in alcohol,	6
Earthy parts soluble in acetick acid,	22
Oxide of iron soluble in muriatick acid,	13
Coloring parts almost pure,	47
	100

There cannot be a doubt, that manufactures of indigo might produce, by attending to the analysis made by chymists, an article far superior to any hitherto offered to the publick. It will also appear certain, when experience shall have confirmed the value of a superior indigo, that a more than remunerating price could be obtained for a purer article. For certain purposes a pure indigo would command double, and even treble prices, provided the supply were not too great for the consumption. This being the case, it would be well for our manufacturers to pay some attention to the subject, and endeavor, by some easy unexpensive process, to bring it to as great perfection as possible. To promote this object, I offer the following extracts and observations.

Bergman dissolved, by means of ebullition in water, a ninth part of the weight of indigo.

Quatremere also separated, by means of water, the parts which are soluble. He states their quantity to be more considerable, the worse the quality of the indigo; and

that, after this operation, the residuum has acquired the qualities of the finest indigo. He therefore proposes to purify what is of inferior quality, by boiling it in a bag, and renewing the water till it ceases to acquire color.

If sulphurick acid be diluted with water, it attacks only the earthy matter that is blended with the indigo, and some mucilaginous ingredients.

Muriatick acid digested or even boiled with indigo, takes up the earthy part, the iron, and a little extractive matter, which colors it yellowish brown, but without attacking in any manner the blue color.

It is evident from the analysis, that to make indigo far superior to any now brought to market, requires only an application of known facts to the art of making it. It is a well ascertained fact, that if indigo be boiled in water containing muriatick acid, twenty five per cent of the impurities contained in the best samples would be extracted, and that the coloring matter remaining would form an indigo far superior to the best now offered for sale.

The best Bengal indigo, and I never knew it in a more depressed state, is worth, wholesale, one dollar eighty cents per pound. The average value of all the indigo imported from foreign countries is about one dollar and fifteen cents per pound, whilst the average value of that made in the United States is not more than fifty cents, and this great difference in the value is owing almost entirely to the great impurity of the article. The first object with our manufacturers, therefore, should be to make their indigo equal in quality to the best Bengal, and the second to go as far beyond them as is practicable.

In the best samples of the indigo of this country there is evidently too much extractive matter, and there is no doubt that this defect arises, in a great measure, from their taking the pulp from the beater, instead of their running it into a vat of clear water, and after well agitating it there, letting it settle in the third vat. This third receiver should undoubtedly be added where it has not been already done. Those manufacturers who would wish to avoid the expense of a third receiver, may fill up the beater with fresh water, after drawing off the first liquor, and perform the operation in the same vat.

The greatest improvement I can at present suggest, would be to boil the pulp taken from the vat by steam heat, for fifteen or twenty minutes, in water containing as much muriatick acid as would give to the liquor a strong acid taste. This operation can also be performed by placing a pipe in the beater from any steam vessel.

Muriatick acid, beside the oxide of iron, dissolves the carbonate of lime, red resin, and alumina, contained in the indigo, and by being mixed with water, the greater portion of the extractive matter would be taken up at the same time. By boiling the pulp in water strongly impregnated with muriatick acid the indigo remaining would be twenty-five per cent better than any hitherto made, and a price, more than equivalent to the difference in the loss of weight and expense of working, would be obtained from the consumer.

I have been informed by some South Carolina planters, that owing to their inability to proceed with the fermentative operation as rapidly as the crops require, a portion is often left on the fields for two or three weeks after the plants have arrived at maturity. This circumstance alone is sufficient to blast the interest of the planters. Their interest would be much better consulted, by gathering in the crop, drying it, and extracting the coloring matter by the simmering process. This difficulty is obviated in Bengal by their planting the seed in successive periods, so that one crop shall ripen, a week or more after the other, each crop being sufficient to supply one set of tanks during the period of maturity.

Dyers as well as indigo planters, would be highly benefited by attending to the analysis of indigo. Were they, when a superior color is wanted, to boil the ground indigo in a bag, as described by Quatremere, there would be no difficulty of obtaining the desired result from indigo of any quality.—(Am. Journal of Science.)

CHARLES CARROL, *of Carrolton, and the* BALTIMORE AND OHIO RAIL-ROAD.

It has been a charge frequently brought against the aged, that they do not enter so immediately into the spirit of the times, as it is called, and the views of young people, as those in middle life; that they become more timid, less venturesome, and not so capable as others of those projects and enterprizes which mark many sections of our own and foreign countries. Without enquiring as to the truth of the above, we have an opportunity of presenting before our readers a

name, (endeared to all we trust, by many considerations) to which has just been added another act of patriotism; the example of which, if followed by all who are able in this vicinity, would soon give us what almost every one deems so essential to the prosperity of our city and commonwealth. We are led to the preceding, by a perusal of the oration of Mr. Alexander H. Everett, delivered in this city on the 5th ultimo, in which he mentions the circumstance to which our attention is elicited, and in which we cannot but express our great gratification, and could but wish that some of the revered names, to the most sacred state paper that ever went forth among the nations, who resided in Massachusetts, were still alive, and our word for it, the name of CARROL would not stand alone as a patron of rail-roads.

In reference to the signing the Declaration of Independence, the orator remarks:

The Declaration being finally adopted, it only remained to engross it on parchment, and affix to it the signatures of the members of Congress. In this way several of them, and among others RICHARD HENRY LEE, the mover of the Resolution, who were absent when the vote was taken, were enabled—as they all desired—to assume their share of the high responsibility connected with the Act. For this purpose the document, fairly engrossed on parchment, was placed on the table of the President, and the members successively rose from their seats and went up to sign it. When CHARLES CARROLL, of Carrolton, crossed the hall, another member sportively remarked, as he passed before him—"*There goes half a million of money at the dash of a pen!*" The clear and beautiful character of his signature evinces that his mind was undisturbed by the sinister prediction. CARROLL was immensely rich; but he reckoned his gold as dross in comparison with honor, conscience and liberty, He chose wisdom in preference to wealth—I mean true wisdom—the wisdom of the Scriptures—which is Honesty, Virtue, Religion: and experience has shown that, in his case, as in every other, length of days is in her right hand; and in her left hand, riches and honor. CHARLES CARROLL, of Carrolton, is the only signer who survives to witness the fifty-fourth anniversary of this great and good day—to receive, as the living representative of his fellow-signers, the grateful homage of the country. He survives with undiminished wealth; and, I may add, with undiminished alacrity to stake it without hesitation upon the result of any honorable and useful enterprize. We heard but lately that he had invested a princely sum, not less, I believe, than *fifty thousand dollars, in the Baltimore and Ohio Rail-Road:* and when we heard it, fellow-citizens, we regretted the more that the race of the Signers of the Declaration was extinct in this vicinity. How beautiful is the evening of such a life! Long may he survive to enjoy the honors he has so nobly earned—the wealth he employs so well—and may he celebrate, in health and happiness, many anniversaries like this, before the grave shall finally close upon the mortal remains of *The Last of the Signers.*

Notice and description of a Marine Ventilator; by Samuel Whiting.

The machine consists of a box, or chest, of dimensions to adapt it to the vessel in which it is used, say from six to twelve feet long; from two to four feet in depth, and from three to six feet wide. This box, or chest, is divided into four compartments, to wit, upper and lower, by a horizontal vibrating midriff, suspended upon an axis resting in the middle of the perpendicular sides of the box, and dividing the space into two equal portions. The ends of the box form segments of the circle which would be described by a revolution of the midriff upon its axis, so that in the vibrations of the midriff, as little air as possible may escape from one compartment to the other. These upper and lower spaces, are subdivided by a middle perpendicular partition, above and below the axis, and so fitted to the same, as to permit it to turn without suffering the air to escape from one to the other division; preserving as little communication of air between the compartments as possible. This midriff is to be operated by pistons, or pitmans, attached to it in each of the upper compartments, and passing through the top of the box, they are connected with a break, or lever, resting in a fulcrum in the centre of the top of the box, and for the convenience of working it, extending at each end beyond the end of the box.

Through the perpendicular sides of the box, and as near the axis of the midriff as may be, without interfering with its motion, are four apertures on each side, to admit and discharge the air. These apertures are governed by valves; one on each side of

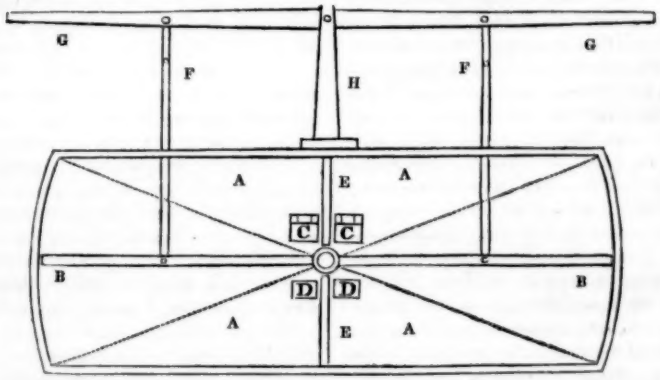
each of the upper and lower compartments, opening inward; and one in each, opening outward; and that transversly. Over each two of the valves, in the upper and lower compartments, respectively, is placed an air-tight cell, calculated to receive a general conductor of air, to or from the valves it covers. Thus on the vibration of the midriff, at the descending end, the fresh air is drawn into the upper compartment through the inside valve, while the foul air is driven out of the lower compartment at the same end, through the outside valve; and *vice versa*.

From the cells which cover the valves, conductors extend respectively to the hold of the vessel, at different and remote parts of it, one to inhale at one part, the foul air, and another, at another part, to exhale the fresh air; while others extend abroad in different directions, one to inhale at one place the fresh air, and another at a remote part of the vessel, to exhale the foul air. Thus a continual current of fresh and foul air, respectively, is passing through the ventilator: the fresh air through the upper compartments, and the foul, in an opposite direction, through the lower; so that a four-fold operation is performed by every stroke or movement of the lever which governs the midriff; to wit, inhaling fresh air at one valve, exhaling fresh air at another; inhaling foul air at one, and exhaling foul at another; and this alternately.

This machine is to be suspended under the deck of the vessel, through which the pistons, or pitmans, by which it is worked, pass; and in the most convenient part: or it may be in a detached and movable form, and worked altogether above decks, or in the vessel's hold. The pipes, or conduits, to convey the air, may be either stout leathern hose, or wooden, or metallick tubes, passing to the different parts of the hold, under the deck.

By the use of this machine, vessels may be ventilated at sea, at any time, in any situation, and in any weather, and a current of pure air be made to pervade the interior of the vessel, while her hatches are kept closed; whereas in the ordinary method, it is only in situations when the hatches can be open, and the vessel at anchor, or in smooth water, that any thing of the kind is attempted, and even then with, comparatively, but partial effect.

Considering the very great importance to commerce and navigation, attached to the preservation of vessels and cargoes, which, especially in long voyages, and warm seasons and climates, depends in so great a measure upon the purity of the vessel's hold; and also the very imperfect manner in which that object has heretofore been ordinarily attained; it is presumed that essential benefit may be derived from this improvement to the community, in those branches of its interest.



A, A, A, A, The four compartments.
B, B, The midriff.
C, C, Two apertures in upper compartments; valves inside.
D, D, Two apertures in lower compartments; valves outside.
E, E, Perpendicular partition.
F, F, Pistons, or pitmans.
G, G, Break, or lever.
H, Fulcrum.
Dotted lines exhibit the sweep of the midriff.

Remarks.—The object of the above invention is important; and as far as we can judge without having seen a working model; and with a limited acquaintance with nau-

tical affairs, the machine is at once ingenious, cheap and simple, and likely to prove effectual.

It is said that a machine for ventilating confined places was invented in England by Dr. Hales; its principles were stated to be similar, but its structure more complex, and not well adapted to marine use; and it does not appear to have been so applied. We understand that Mr. Whiting intends that his machine should be used in prisons, hospitals and other situations, which it may not be convenient always to ventilate in the usual modes, and in every case of this kind, it is obviously susceptible of useful application. Even where chlorine and its preparations have been used to destroy noxious effluvia, it may be, and generally would be necessary that the premises should be afterwards ventilated, and their situation might render it very desirable to use such a machine as the marine ventilator.

It might be used, with much advantage, in removing the carbonick acid gas (the damp of the common people,) from wells, as bad air would be replaced by good, and if there were no source from which the noxious gas might flow in again, the cure might be permanent.—(Prof. Silliman.)

Magnetick influence of the Violet Ray.—The power of the violet portion of the solar spectrum to convert a steel needle into a permanent magnet seemed to have been well established by Prof. Morichini in 1812, and confirmed by Mrs. Somerville in 1826. But other philosophers having failed to obtain results which they deemed satisfactory, some doubts appear to have prevailed with respect to the certainty of such an influence in the violet ray. Prof. Zantedeschi, of Pavia, in an article communicated to the Bib. Univ. of Geneva, states, that having placed the extremity of a well polished soft iron wire four inches long, and one fourth of a line in diameter, to the violet spectrum, kept in its place in a dark chamber by a Heliostat, he found that in the course of five minutes, the wire when presented to a magnetick needle, manifested very decidedly the existence of poles.

The violet ray changed or reversed a well marked pole in a soft iron needle.

The red, yellow, orange and green ray produced no alteration whatever in a magnetick needle, nor in one which had no sensible magnetism.

A soft iron wire, covered with a coat of oxide, and strongly magnetized, exposed to the violet light, in three minutes, had its south pole transformed to a north pole.

A soft wire, magnetized, being bent, and both ends exposed to the violet ray, in ten minutes, both ends became north.

If the wire was oxidized, this change was effected in five minutes.

These experiments were so often repeated as to leave no doubt of the magnetizing property of the violet ray.

In the course of his investigation, Prof. Z. ascertained that iron obtained from a sulphurous mine, could not be thus magnetized, nor was it easy to produce much effect upon iron highly tempered.

At low temperatures, also, such as 6° R. 0, + 10° the results are very equivocal. But at + 20° Centig. the temperature of Mrs. Somerville, or at 25° or 26° R. that of Prof. Z. the results are very striking.

If the middle of the needle be placed in the violet ray, the effects are weak or uncertain.

Perceiving that the carburets could acquire magnetism and not the sulphurets; that needles artificially oxidized, presented the phenomenon in question more promptly than those which are not so, and that the effect increases or diminishes with the temperature, Prof. Z. is confirmed in the opinion that the action of the violet ray is chymical. The light of a candle gave him, in three fourths of an hour, a slight degree of magnetism, but the violet light of the moon had no effect. The latter was tried, however, at a temperature not exceeding 5° R.

Prof. Z. finds his needles retaining their magnetism, at the end of eight months.—(Bib. Univ. Mai, 1829.

Gold and Platina.—An account is quoted in the Annals of Philosophy, from a Prussian Journal, from which it appears that rich beds of Platiniferous sands have been recently discovered throughout the western branch of the Uralian mountains.—Banks of greenish gray argilaceous sand, varying from two and a half to five feet in thickness, lie near the surface under a covering of turf and contain from one to three pounds of metal in three thousand and seven hundred pounds of sand.

The Asiatick side of the mountains is rich in gold. Documents supplied by Professor Fuchs, show that from the beginning of summer to the month of August in the same year, seven thousand seven hundred and ninety-two workmen were employed

in the gold washing, and that they procured fourteen hundred and sixty pounds of pure gold. From the first of May to the first of October, two thousand eight hundred and twenty-four pounds, and some ounces, of gold were obtained from about two hundred and seventy thousand times its weight of sand; masses of gold occurs frequently but a few inches under the grass.

In concluding M. Arago on the explosion of boilers, we cannot refrain from expressing a desire that the attention of the publick, and particularly the scientifick, may be turned towards it. It is a subject of too much moment to "pass silently away." The preservation of life, and the retention in use, of one of the greatest of human inventions, demands, at the hand of every man, an active investigation into the various causes of explosions. None can tell what discoveries are within his reach, or know how much he can contribute to the publick safety; we, therefore, invite human scrutiny to the task, and hope that an effectual and complete remedy may yet be found; that the ingenuity of man may yet say to this leviathan of power, "thus far, and no farther, shalt thou go." When this is accomplished, the steam engine may be truly considered as the noblest work of human invention.

On the Explosion of Boilers of Steam Engines. By M. Arago.

(Concluded from p. 180.)

Explanation of the explosions which are preceded by the opening of the safety valve, or by a diminution in the elasticity of the steam.

How does it happen that a boiler bursts at the very moment of the opening of the safety valve? How does it happen that this accident is almost always preceded by an apparent diminution in the elasticity of the steam?

These questions, involving seeming paradoxes, are suggested by the accidents recorded in this paper. Mr. Perkins has, I think, answered them satisfactorily, and I shall lay before the reader the explanation given by that engineer.

In a boiler of the common construction, when the flame from the furnace does not rise higher than the level of the water within, the metal and the liquid inclosed, are of the same temperature. This is no longer the case when there is not a proper supply of water in the boiler, and when the flame rises high; then, parts of the boiler may be heated even to redness; in such a case, the steam in contact with the intensely heated metal would become very hot, and yet not acquire great elasticity, either because it is not fully saturated with moisture, or from another cause which I shall explain hereafter.

The water within the boiler being thus low, and the steam which presses upon its surface very much heated, but of little elastick force, suppose the safety valve to be opened; a copious discharge of steam takes place; the water relieved from the pressure upon its surface, rises up in foam, the action being similar to that which takes place in a Champaign bottle on drawing the cork; the water thus thrown in small drops into the midst of an intensely heated vapor, flashes into highly elastick steam; the safety valve not affording a sufficient vent for the discharge of the steam, the boiler is rent.

There are three hypotheses in this explanation. The first is, that the part of the boiler, above the level of the water within, may become intensely heated, and may communicate heat to the steam within, without affecting, materially, the temperature of the water upon which this steam rests. The second is, that boiling water is projected to a certain height in the form of froth as soon as the elasticity of the steam, pressing upon its surface, is suddenly diminished. The third, that water thus disseminated through a mass of heated steam, is itself suddenly flashed into steam.

No one, I think, will refuse assent to the first hypothesis. If a metallick vessel, placed upon a fire, does not become heated to redness, it is because the water within continually deprives the metal of the heat which it receives from the fire, thus preventing an accumulation of heat in the metal. Steam could not produce this effect in the same degree. If the flame from the furnace should play upon a part of the boiler above the level of the water within this part might become heated to redness, and communicate its temperature to the steam in contact with it; this stratum of steam, in its turn, would communicate the same temperature to an adjacent stratum, and so on, until the heat should be disseminated through the body of steam occupying that portion of the boiler not containing water; that is, through the steam reservoir. There

are examples of these effects. Mr. Moyle, in visiting his engines in Cornwall, found that one of the boilers had become so hot that a wooden scale resting *upon the top* of the boiler had taken fire. A similar occurrence took place on board of one of the packets between Liverpool and Dublin; a pine board, accidentally thrown upon the cover of the boiler, took fire. I have already stated, that before the accident at Pittsburgh, the engineer had observed, for some days, that one of the boilers became heated to redness. I will now give a direct experiment of Mr. Perkins, upon this subject.

A cylindrick boiler, of four feet in length, and one foot in diameter, having been placed, vertically, over a furnace, the base was surrounded by a fire, which rose to one third of the height of the cylinder, while the water occupied but one sixth. Thus, two sixths of the surface of the vessel were exposed to the heat; one sixth above, the other below, the level of the water within. The safety valve, loaded with about one atmosphere, was placed in the side of the boiler, half way up. Water was supplied to the boiler so as to make up for the loss from the escape of steam.

A thermometer immersed in the water, and going down to the bottom of the vessel, indicated a temperature of 104° (219° Fah.) The temperature of the stratum of steam, resting upon this water, was the same; but half way up the boiler the thermometer stood at 260° (500° Fah.) and the metal was *red hot.*

The first hypothesis being established, we pass to the second.

There are liquids which, when boiling, are thrown upwards with violence; sulphurick acid is one of these; milk is another example; but the commotion is not so violent as in the case of the acid. If we examine, attentively, water while boiling, we shall see that, at times, small drops are thrown upwards to some distance. This action depends, evidently, upon the viscous nature of these liquids, and on the difficulty with which steam, generated at the lowest part of such liquids, finds its way through them. When the quantity of confined vapor is great, and it is prevented from escaping by a pressure upon the surface of the liquid, it is easy to see that if the pressure be suddenly removed, instead of rising gradually, as in ordinary circumstances, it will escape very rapidly; that the liquid will froth, as though impregnated, under pressure, with a gas; will become a kind of foam, consisting of water and steam; will have its bulk very much increased, and will expand throughout the boiler. A direct experiment, made in a transparent vessel, would show how far these deductions are correct; wanting this, we conclude by reasoning from analogy, that, as Mr. Perkins asserts, in case of a sudden diminution in the elasticity of the steam within the boiler, the water may rise above its level, and its foam may fill the whole of the steam reservoir.

Let us pass to the third hypothesis of the American engineer, viz: the *sudden* conversion of water into steam. Here we shall have direct experiments to guide us.

Mr. Perkins having filled one of the metallick cylinders, which he terms generators, with water, raised its temperature to 500° Fah. By the side of this cylinder was placed a close receptacle, containing neither water nor dense vapor; its temperature being about 650° Fah. These two vessels communicated through a tube, usually closed by a valve.

It is evident that if, by means of a forcing pump, a small quantity of water be thrown into the generator, an equal quantity of the hot water within must be forced out, and opening the valve connecting the generator with the receiver, must pass into the latter; when, by the use of a properly adjusted valve, it might be made evident whether the water was converted suddenly into steam or not.

Mr. Perkins states that the conversion of the water into steam was instantaneous; that the injection pump had hardly made its stroke, when the valve of the recipient indicated a pressure, from the elasticity of the steam within, of forty atmospheres when a moderate quantity of water was injected; of one hundred when the quantity injected was great.

If this experiment had been made with water heated to from 212° to 250° Fah. it would show, exactly, what must take place in a boiler of the common kind. Since the temperature of the water used, 500° Fah. is far below that of steam, having an elastick force equal to 100 atmospheres, this experiment further shows that a portion of the water has flashed instantly into steam, on leaving the generator.

It cannot be inferred from the experiment just given, that the water is flashed into steam by the agency of a very rare steam, the temperature of which is that of red hot iron.

This part of the opinion of Mr. Perkins, as has been remarked by M. Dulong, could hardly be reconciled with the known laws of the specifick heat of steam. We are therefore, induced to believe that the American engineer was wrong in supposing, that the heated metal had no direct agency in the results observed.

Let us now examine whether, setting out with the fact of the sudden conversion of water, in contact with intensely heated metal, into steam, we can give a satisfactory explanation of all the accidents which have been detailed in the former part of this paper.

The explosion described by M. Gensoul confirms precisely the view taken by Mr. Perkins. It may be explained by supposing that on turning the cock, thus giving vent to the steam in the boiler, the water, suddenly relieved from the pressure which it had borne, rose in foam within the boiler, and being thus thrown in contact with the faces of the boiler, which were, probably, highly heated, it was converted so rapidly into steam, that the cock did not afford a sufficient vent for its escape.

The same reasoning applies to the experiment of MM. Sabareau and Rey, for their boiler being very small and exposed directly to a charcoal fire, the part above the level of the water might have been surrounded by flame. In the experiment made by M. Dulong and me, no increase of pressure resulted from opening the safety valve, because the boiler being large, and the opening through which the steam issued small, the elasticity of the steam within was very gradually diminished; besides which, the boiler was placed upon a bed of masonry, and only the part containing water was exposed to the fire. The diminished action of the engine, which preceded the explosion at Essone, the one at Paris, and that of the Etna in America, seems to me to be accounted for naturally, by the cause assigned for it by Mr. Perkins. It has been seen, that when the explosion has happened in consequence of some defect in the feeding pump, or in the pipe leading from it to the boiler, the level of the water in the boiler was lowered; now the quantity of steam, generated in a given time depending upon the extent of heated metallick surface in contact with the water, if this extent were calculated, at the original level of the water in the boiler, to afford a due supply of steam to the engine, it follows that when this extent has been diminished, by a reduction in the level of the water, the boiler can no longer furnish a quantity of steam sufficient to supply the wants of the engine. It might be supposed that the increased temperature of the steam, produced by contact with the heated sides of the boiler, by increasing its elasticity, should compensate for the diminution in quantity; it is easily shown that this cannot be the case. The steam contained in a given vessel, must every where be of the same elasticity. The elasticity of the stratum of steam in contact with the water in the boiler, is determined by the temperature of that water; the upper strata must have the same elasticity with the one in contact with the water; hence, the steam, heated by contact with the sides of the boiler, must have an elasticity determined by the temperature of the water.—The boiler will contain steam of a density less than that of saturated vapor of the same elasticity; this is all that can take place.

Mr. Perkins supposes, that the very moment in which the explosion takes place, is that at which the safety valve opens; the steam within the boiler has then reached the limit of elasticity under which the engine was to work; at this very limit the piston of the engine must move slowly, for the steam, being much warmer than the metal of the engine, must lose much of its heat, by imparting it to the cooler metal, and, therefore, much of its elasticity.

It would, I think, be fruitless to endeavor to determine from this, or from any other theory, the form of the line of rupture of the boiler; the number and size of its fragments; the directions under which they will be projected, &c. &c. A thousand circumstances would modify these results, in ways which it would be difficult to determine, even if the action took place slowly, and before our eyes. It happens, however, so often that the line of rupture is horizontal, that it appears natural to suppose this line to have marked the level of the water within the boiler, at the time of the explosion; and, therefore, it is a curious question to determine why this line, notwithstanding the inequalities in thickness of the metal at different points of it, should be the line of least resistance. This fact can, I think, be explained as follows:

At the very instant which precedes an explosion, the elasticity of the steam is very much, and very suddenly diminished.—This must produce a flexure in the boiler towards the interior; but, as this motion is

communicated suddenly, the inertia of the liquid will prevent its immediate effect upon that part of the boiler which contains water, since this inertia cannot be at once overcome.

The boiler will then be caused to bend inwards, along the line of the level of the water which it contains. But we have seen that the formation of a highly elastick steam follows immediately the opening of the safety valve; by this steam, the sides of the boiler will be pressed outwards. Now even if we suppose this force to act, at the same instant, equally on every part of the boiler, still, that part containing the liquid will not yield at once to the impulse, for reasons stated in considering the inward flexure. The level of the water in the boiler, before the explosion, will therefore trace, upon the faces, the line in which the flexures, both inward and outward, ceased to produce an effect, the only line along which contiguous particles of metal have not the same motions. We need have seen but once the ease with which plates of metal are broken, by bending suddenly in contrary directions along a certain line, to understand why the line of level of the water within the boiler, inasmuch as it is the hinge, about which the two flexures take place, should usually be the line of rupture, although, as at Lyons, it would not be, if we had regard only to the thickness of the metal, every where the line of least resistance. It is important further to remark, that this is the line along which the metal becomes of a higher temperature than the water within, and which, consequently, divides the boiler into two parts, of very unequal tenacities.

The almost simultaneous explosion of several boilers employed in supplying the same engine, was noticed, in a former part of this paper, as a fact worthy of attention, and one which it was important to be able to explain. Would this explanation be difficult if we admit, with Mr. Perkins, that an explosion is generally produced by the depression of the level of the water in the boiler, and the heating of the metal above this level? Might we not say that these circumstances generally occur at the same time in the several boilers? since they are fed by the same pump, and since, as soon as the engine moves slowly, the firemen would naturally urge the fire in each furnace. This being the case, let us suppose that one of the boilers bursts on the opening of its safety valve. The pipe, through which steam passed from this boiler to the cylinder of the engine, is open to the air; each boiler has a similar pipe, and all terminate in one and the same pipe. By this means, the second, third, &c. boilers communicate with the atmosphere; the steam which they contained pours forth through this wide opening, and, in an inappreciably small portion of time, the circumstances producing explosion are to be found in each boiler, without the necessity of supposing that the safety valve of each was raised at the same instant.

I have spoken of a boiler which exploded in the air. In all probability, when that at Lochrin burst, it was twelve or fifteen feet above the bed of masonry which usually sustained it. Although this fact can be equally well explained by several theories which have been advanced to account for explosions, and therefore cannot determine us to adopt one of them rather than another, still, it may not be superfluous to show that it can be perfectly well explained by that of Mr. Perkins.

The supposition was an erroneous one, that a boiler, composed of metallick plates, must, necessarily, remain in its place, when an opening should be made in any part of it. This error, into which, for example, many of those who contrived the portable gas lamps fell, might cause severe accidents. It is true, that a vessel, completely closed, remains at rest, whatever be the elasticity of a gas within it; but this is because the pressure upon any point of the vessel is exactly counterbalanced by that upon the opposite point. The effect of a pressure from within, upon the top of a vessel, tends to raise the top; and if the force were sufficient, the top would rise, were it not that the pressure upon the bottom, in a contrary direction, is exactly equal to, and destroys the first force. Now it is evident that the same effect is produced, whether we destroy this downward force, or take away the part of the boiler which served as its support.

The unresisted force, which produces motion in cases analagous to the preceding, is called *reaction*. An example of the effect of this force, is afforded in the flight of the rocket; the gas resulting from the inflammation of the powder, finds, on one side, no resistance, and on the other, a base, against which to act; it therefore drives the rocket forward by virtue of this action. These preliminaries established, a few words will suffice to show how, ac-

cording to the theory of Mr. Perkins, a boiler may explode in the air.

The explosion is, according to this theory, always preceded by a copious formation of steam. When this steam escapes through the safety valve, placed, as it generally is, upon the top of the boiler, the *reaction* of the steam tends to press the boiler more firmly upon its bed; but if the steam escape through some fissure in the lower part of the boiler, the boiler may be projected upwards; being then acted upon by a force directed similarly to that which produces the flight of a rocket. This effect must take place if the elasticity of the steam should be sufficiently great. Add to this, that the change of situation of the boiler, producing a corresponding change in the position of the liquid within, cannot fail to give rise, independently of other causes already mentioned, to the instantaneous production of steam, which causes an explosion.

It seems then, that the theory of Mr. Perkins explains, satisfactorily, all the examples of explosions which I have been able to collect, which were preceded by a decrease of elasticity in the steam. Since, in addition to this, the theory is not at variance with known physical laws, we ought immediately, if not to adopt it, at least to take the precautionary measures which it suggests.

These measures are very simple.

To prevent by every means in our power, for example, by the use of fusible metal plates, any part of the boiler from becoming heated too highly.

To pay the greatest attention to those means by which the boiler is supplied with water, or to those which indicate the level of the water within the boiler.

If, notwithstanding the precautions of the engineer, parts of the boiler should become too intensely heated, to avoid every abrupt opening of the valves, or operations of an analagous sort, which will permit the steam, already generated, to flow rapidly into the air.

Lastly, in such a case to put out the fires as quickly as possible.

Comparison of the explanation given by Mr. Perkins with those offered by other engineers: new causes of explosions.

Although I have presented in detail, and under a favorable point of view, the explanation given by Mr. Perkins, of the causes of the dangerous explosions, which, notwithstanding the good condition of the safety valves, too often occur, I am far from considering this explanation so conclusive as not to admit of a doubt, and, in consequence, to suppose the subject exhausted. I will, therefore, now present views upon the same subject, which I have derived from the printed, and manuscript works which I have been able to consult; and also will subjoin a notice of certain causes of explosion, not spoken of by the American engineer. I shall then have completed the task which I proposed to myself, namely, to give as complete a statement as was possible, of the information which has been acquired, in relation to these distressing accidents; those who may deem it necessary to extend this knowledge will know the point from which they should begin.

One of our most skilful naval constructors, M. Marestier, has offered a theory, in relation to the particular kind of accident which Mr. Perkins had in view; which, viewed as a whole, has some analogy with that of the American engineer; there is one point, however, upon which these authors differ essentially.

M. Marestier admits, with Mr. Perkins, that for some time previous to an explosion, the boiler has not received a sufficient supply of water; that one portion of the metal thus receiving the direct action of the fire, without being in contact with water, becomes heated, perhaps even to redness; that, at the moment in which the safety valve opens, or an accidental escape of steam takes place, the surface of the water is disturbed, as has been already explained, either in consequence of the violent ebullition caused by a diminution of pressure within the boiler, or by the flexure of the boiler inwards, which lessens its capacity. M. Marestier further supposes, that the water, thus raised, coming in contact with the heated metal, is suddenly flashed into steam, and in such abundance, that the safety valve cannot give vent to it. In the boilers of steam boats, in certain cases, the motion caused by the waves tends to bring the water in contact with the heated metal.

The reader may recollect that Mr. Perkins attributes the sudden production of steam, to the projection of water into steam of a very low density, but intensely heated; whilst that, according to the explanation of M. Marestier, just given, it is the heated metal which suddenly flashes the water,

thrown into contact with it, into steam. Nothing at first sight could appear more in accordance with reason than this hypothesis of M. Marestier; but in natural phenomena, as has been wisely remarked by Fontenelle, "as soon as two different causes may be supposed to account for an effect, the true cause is generally that which at first seems the less probable." It is the fact, however strange it may appear, that metal, heated to redness, does not rapidly convert water into steam. If a drop of water be placed in a vessel heated to a white heat, its conversion into steam requires a long time, while it disappears at once if thrown into the same vessel when but moderately heated.

The only experiment which I shall cite upon this point, is that of Klaproth: a drop of water thrown into an iron spoon, heated to a bright red heat, required 40 seconds for vaporization; at the end of this time a second drop let fall into the same spoon, now partially cooled, required but 20 seconds for vaporization; a third drop disappeared in 6 seconds; a fourth, in 4; a fifth, in 2; and a sixth, in an inappreciably small portion of time. Notwithstanding these curious observations, I have already stated that the *intensely heated* metal of the boiler appears to me to play the principal part in that sudden transformation of water into steam, which causes an explosion: it must be admitted, however, that to complete his theory, M. Marestier should be able to explain, why the water within a boiler acts differently from the drops in the experiment of Klaproth. If it were found that a drop of water, thrown violently against an intensely heated plate of metal, is instantly converted into steam, all our doubts would disappear, and the explosion of the boiler, known to have been heated to redness, at Pittsburgh, would no longer seem an anomaly, requiring new causes to be sought for its explanation. In conclusion I would remark, that Messrs. Perkins and Marestier only differ upon a point of theory. The fact of the sudden conversion of water into steam, determined experimentally by the former, is admitted by the latter; and with regard to the precautions to be taken to guard against explosion, it is of no consequence whether the heated metal acts directly or indirectly in the formation of steam. The same care should be taken to prevent the boiler from becoming too highly heated; and if it should become, by accident, thus heated, to prevent the sudden opening of the valves.

M. Gensoul, whose name is so honorably connected with the progress of the useful arts at Lyons, explains very differently from Mr. Perkins, or M. Marestier, the explosive effects produced, sometimes, by the sudden opening of a safety valve. The following may be considered an outline of M. Gensoul's theory:

When a metallick tube is filled with a liquid very strongly compressed, a slight blow upon the face of the tube will cause it to burst, while a great increase of pressure, gradually applied, might have failed to produce such an effect. This fact is well known; M. Gensoul thinks it may be extended so as to apply to boilers. In his view, when the faces of a boiler have been pressed with great force, by the steam within, they should break by a small percussive force, just as if they contained a liquid subjected to great pressure; now he thinks, that the part of a boiler diametrically opposite to that on which the safety valve is placed, must experience a sort of percussive action when the valve opens suddenly, allowing the escape of steam. If, for example, the safety valve is on the top of a boiler, the bottom will receive the percussion on the opening of the valve; if the right side of the boiler should have the safety valve attached to it, then the left would be struck, &c. &c.

This ingenious explanation raises several doubts in the mind. First, it appears by no means evident that, the interior pressure being the same, a blow can produce the same effect upon a vessel filled with a liquid and with a vapor; the incompressibility of the liquid may be of some importance in this action. Secondly, M. Gensoul supposes that before the explosion the boiler is filled with a highly elastick vapor, while, on the contrary, we have seen that such accidents often happen when the engine is working very slowly. The explanation seems at least incomplete. We may, therefore, conclude, that in cases of sudden rupture, the reaction of the steam escaping can produce no important effect; I have pointed out the kind of accidents which may be produced by this cause.

Some persons, struck with the instantaneous effects produced by the explosions of boilers, have been induced to think that steam alone could not produce them, and have called to their aid gases capable of exploding. Why, say they, since, in the

laboratory, hydrogen gas is obtained by passing the vapor of water through an iron tube, heated to redness, will not the same gas be produced within a boiler in which the steam is sometimes in contact with metal heated to redness? We grant that this would account for the production of this gas. Mixed with steam, this gas will pass into the cylinder of the engine; from hence, as it is not capable of condensation, it will be expelled at a great expense of power, and the effect will be to retard the working of the engine. I will admit, if necessary, that this is usually the cause of the retardation in the working of an engine, just before an explosion, in the kind of accidents which we have been engaged in discussing; but how is this explosion produced? Hydrogen alone, or when mixed with steam, cannot explode. A mixture of hydrogen and oxygen gases, in proper proportions, will explode; but how are gases to be produced within the boiler? The hydrogen is produced by the decomposition of water by the heated metal, which is thus oxidized; from whence, then, can the oxygen come? Perhaps it may be said, from the atmospherick air contained in the water which feeds the boiler; but we may answer, that this water is generally warm; that it contains, therefore, but a small quantity of air; and, moreover, that this air, as fast as it is disengaged from the water, passes in a state of mixture with the steam, into the engine. Further, it may be added, that the oxygen of this air would combine with the heated metal more readily than that contained in the water would do; and thus, if hydrogen gas should be produced from the water, it would find nitrogen present with which to mix, but no oxygen. If even this difficulty were disposed of, we should be no further advanced. The only means known by which hydrogen and oxygen gases can be made to unite with explosion, are a solid body heated to redness, flame, and the electrick spark. Boilers have burst without having reached the temperature of redness required to produce an explosion. Flame is still further out of the question. There remains the electrick spark; from whence shall we derive it? I know it has been said that the explosion of the boiler of the steam boat Enterprize, of Savannah, was caused by an electrick discharge, to which the smoke from the chimney of the furnace had served as a conductor; but, supposing this to have been the case, we have no evidence that the lightning found a mixture of hydrogen and oxygen gases in the boiler, or that it did not act as it usually does, rending asunder every thing which it meets. But even admitting, with the partizans of the theory which I have just explained, that the electrick spark may possibly be the cause of an explosion, I cannot persuade myself that this agent can be supposed to act, I will not say in all, but in the one-hundredth part of the cases of explosion.

Discouraged by the difficulties of uniting, in the same boiler, the gases necessary to form an explosive mixture, some engineers have supposed but one formed hydrogen; that this gas, after the bursting of the boiler, mixing with the air in the furnace, explodes. Thus, the detonation of the gases is not considered as the cause of the explosion, but as adding to the violence of its effects: this explosion taking place in the furnace would project to a great distance, the whole boiler, or its fragments, with those of the furnace. What can I say of these views, but that not a single explosion has occurred in which it has been ascertained that hydrogen, contained within the boiler, has contributed to produce it.

Let us now examine whether, as many engineers have supposed, the elements to produce detonation, may not be found in the furnace itself.

According to these engineers, carburetted hydrogen will be produced from the coal, as in the apparatus for procuring coal gas, and pure hydrogen, if necessary, by the decomposition of the water, which finds its way between the imperfectly fitted plates of the boiler and falls upon the coal. As for the oxygen, without which there could be no explosion, it is derived from that portion of the air supplied by the draught, which passes through the fire without being entirely deprived of its oxygen.

The bright columns of flame, sometimes seen at the tops of the highest chimnies of furnaces, show that the gas, drawn up by the draught, may sometimes form an explosive mixture. If such a mixture should be formed in some corner of the flue, its explosion must be feared. If this explosion should be violent, it is difficult to conceive how the boiler could resist it.

I have already stated how an explosive mixture might be formed in the furnace itself. I must add, that there are certain accidents evidently produced by this cause, I

mean the explosions of evaporating pans entirely open at the top. I am informed by M. Gay Lussac, that the furnace of a saltpetre refinery at the Arsenal of Paris, was recently destroyed entirely, by an explosion of this sort; the boiler remained uninjured.

To prevent such accidents, ascending and descending elbows in the flues should be, as much as possible, avoided; for it is principally in these elbows that inflammable mixtures can be lodged. It is also necessary that the register of the flue should not shut too tightly, as I have explained already. Lastly, to avoid the disengagement of combustible gas from the coal, without its being burned at the instant of its production, care should be taken to have interstices between the bars of the grate of sufficent size. If the coal is rich in bitumen, it cakes, the different pieces become so agglutinated as to form a crust, which, when very thick, is almost impervious to flame. The furnace becomes then a true apparatus for the distillation of the coal, much inflammable gas is produced, and but little heat. The coal should, therefore, be placed upon the grate in thin layers, not only from considerations of economy, but actually from those of safety. The firemen who through laziness encumber the grate with coals, retard the working of the engine, expose it to the most serious accidents, and risk their own lives; they cannot be watched, therefore, with too much care.

To complete my task, there remains but to mention a last cause of explosion, which is not without importance.

The water used to generate steam is very seldom pure. Usually this water contains saline matters, which are deposited by boiling, and which form upon the interior of the boiler a hard crust, which increases in thickness every day. Before the existence of this crust, the heat absorbed by the metal was rapidly transmitted to the water, and the boiler could never acquire a very elevated temperature; as soon as a substance which conducts heat but slowly, as is the case with the saline deposit supposed, lines the interior of the boiler, the heat reaches the water but slowly; the metal receiving, every instant, more heat from the fire than the saline deposit takes from it, becomes more and more heated, until at last it may become red hot; this is not only attended with a great loss of heat, but with great danger, for the metals when intensely heated lose much of their tenacity. We can easily see, besides, the danger lest the comparatively cold water of the boiler should, through some fissure in the saline crust, come in contact with the heated metal. In such a case a boiler of cast metal would, probably, instantly give way, and one of wrought plates would be very much strained, even if its strength prevented its bursting. I may add, that the portions of metal, thus heated, become oxidized very rapidly. As an example, may be cited, the boiler intended to warm one of the noblest works of our capital, in which a hole was burned in the lower part, in the place upon which a workman had, by accident, allowed a cloth to fall.

We thus see how important it is that the boiler should be kept clean. In steam boats which use salt water to supply the boiler, the saline deposit should be removed every twenty-four hours, if not oftener. When the water used is pure, this operation is only necessary at considerable intervals of time. No general rule can be given on this head; the engineer should determine, experimentally, in what way, and how rapidly the saline elements are deposited, from the water which is used in the boiler of which he has the charge. Since the discovery that potato starch and malt prevent these deposits from taking place, it has been proposed to throw a certain quantity of these substances, from time to time, into the boiler; but I do not know that this practice has extended very widely.

I regret that it is out of my power to give an account here of the ingenious researches which M. Tabareau has made on the subject of explosions, the results of which he has presented to the academy; it seems to me necessary to await the modifications in his theory, which he himself has thought necessary.

I ought not to conclude so long a paper on the subject of the explosion of steam boilers without explaining why I have not separated the examples of the explosions of high pressure boilers from those of the low pressure; it is because I think there is no reason to make such a distinction.—Every one must in fact admit, that at the time of an explosion, all boilers contain high pressure steam. I may add that it does not appear established by any means, that explosions take place more frequently in high than in low pressure boilers; the contrary has been maintained by different engineers, among whom may be classed Messrs. Perkins, Oliver Evans, &c.

COMMUNICATION.] [FOR THE MAGAZINE.

On the Effects of blowing Hot and Cold Air into Furnaces.

The late discovery that a saving of fuel may be made by heating air before it is blown into iron smelting furnaces, has seemed very strange, and excited much interest. Several hypothesises have been advanced to explain it, but no correct explication has, to my knowledge, been given. Having formerly made some experiments on calorick, I will attempt to explain this matter, or give my views on the subject. In doing this, I shall advance no theory respecting the *nature* of calorick; that is, whether it is a peculiar kind of matter, or a peculiar motion; what I here offer, will be equally applicable, whichever theory be true.

In most cases, where great heats are required, the quantity of air which passes through the fire, is unimportant, provided the fire be kept at the necessary heat, or, in other words, if the same temperature could be kept up by a smaller quantity of air passing through the fire, it would answer the purpose just as well. To burn one pound of charcoal, 2·8 pounds of oxygen, or 13⅓ pounds of atmospherick air is required. Supposing it would produce 20,000° of Fahrenheit heat, or raise the temperature of the air from 50° to 20,050°, if no calorick were lost by radiation or conduction, it is evident that if the air, when blown into the fire, were at the temperature of 50°, no greater heat than 20,050° could be produced. If a part of the fuel and air be used to heat the remaining portion of air, contained in boilers or other vessels so constructed, that as the hot air passes the chimney it will come continually in contact with vessels which contain air less heated, it may communicate to it a temperature, very nearly proportional to the quantity of fuel burned. If one third of the fuel be burned for this purpose, it may give this air a temperature of one third of 20,000°, at least, which, added to 50°=6716°. If the remaining two thirds of fuel be burned in this air, it would raise its temperature 20,000°, which, added to 6716°=26716°, which will be the temperature of the fire when the hot air is used. Suppose a furnace be required to be kept at 18,000°, and that the quantity of calorick which would escape the furnace in a minute, if no air passed the fire, would be sufficient to cool it 4000°; hence, this quantity of calorick must be supplied the furnace per minute. It is evident that the air which is used for combustion, must be, at least, of as great a temperature as the furnace, or at 18,000° when it leaves the furnace. When cold air is used for combustion, it could impart only 20,050°—18,000°=2,050° of its heat to the furnace. When the heated air is used for combustion, the same quantity of air would impart 26,716°—18,000°=8,716° of calorick; but in this case, the one pound of fuel could supply only two thirds the quantity of hot air, which would reduce it to 5,811°. Hence, the quantity of calorick which the same combustible would give the furnace in the first case, is to that in the second, as 2050 is to 5811; therefore, to keep up the same heat by heating the air before it is blown into the furnace, the quantity of combustible may be diminished in this ratio.

It will be perceived, that if a greater heat were required, a greater saving in fuel may be made; but if a less heat were wanted, a less, or no saving, or even a loss would be made if one third of the fuel should be burned to heat the other two thirds of air; still, a small saving may be made by using only a small portion of the fuel to warm the air a little before it is blown into the furnace. When the weather is warm, a little greater temperature could be produced by the same fuel, were it not for the opposite tendency produced by the atmosphere's generally containing a larger quantity of water, in solution; for this and other reasons, I think, that the variations in the warmth of the weather may be neglected in this investigation, without material error. I shall therefore consider the temperature of the atmosphere as being invariably at 50° Fahrenheit, and reckon the degrees of heat from this point; this will simplify the investigation very much. When the heat which can be produced, by burning the kind of fuel used in cold air, and the necessary temperature of the furnace, are known, a formula for ascertaining the portion of fuel which should be used for warming the air to produce a maximum effect, may be obtained as follows: Let A denote the required temperature of the furnace, B the greatest temperature which can be produced when cold air is used for combustion, C the whole quantity of air used for burning a given quantity of fuel, x the quantity used for heating the remaining air, and y the temperature given to the air before it is blown into the furnace.

Then B×C=the whole quantity of caloriek evolved, and (C—x) A=the quantity which passes with the air from the furnace, and x y=the quantity which escapes with the air used for first combustion; hence, B C—(C—x) A—x y=the quantity which is to supply the waste of the furnace. We readily infer from the above statement that

$$C : x :: B : y = \frac{B\,x}{C}$$

by substituting for y, its value in the above equation, it becomes $B\,C-(C-x)\,A-\frac{x^2 B}{C}$

by making C=1 it is reduced to B—(1—x) A—x^2 B. To determine when this quantity is a maximum, differentiate, and put its differential equal to zero, which will be A d x—2 B x d x=0.

$$A-2\,B\,x=0,$$
$$2\,B\,x=A,$$
$$x=\frac{A}{2B}.$$

To give an example of the application of this formula, suppose the required temperature of the furnace to be 10,050° or 10,000° warmer than the atmosphere, and the greatest heat which can be produced by the kind of fuel used, with cold air, to be 12,000°; then

$$x=\frac{10000}{2\times 12000}=\frac{5}{12}$$

Therefore, in this case, a little less than one half of the fuel should be burned for heating the remaining portion of air before it is blown into the furnace.

It is readily inferred from this formula, that by heating the air in this way, a heat can never be produced which shall be twice as great as that obtained by burning the fuel in cold air, though it may come very near it, for in this case, x would equal the whole quantity of fuel to be burned.

We have seen that by heating the air in this way, a furnace may be kept at a given temperature by consuming a less quantity of fuel than by the ordinary method. Let us next give our attention to the effects of keeping an iron smelting furnace at a temperature a little different from usual. Most iron ores require as great a heat to fuse them, as can be easily produced by common furnaces. Two or more kinds of ores are usually mixed, and lime added to make it melt, and to make the earth separate from the metal; but this does not always completely effect its end; some of the iron remains combined with the earth, and some of the iron which has separated into globules remains suspended in the *scoria*, because it is not sufficiently fluid to allow the iron to sink to the bottom. If the temperature of some furnaces were kept much lower than usual, the smelting would go on *very slowly*, or cease entirely, so that the ore might be kept in the fire for months, without its being reduced to a metallick state. If the temperature were kept a little higher than usual, the ore would be completely fused, and the slag would be sufficiently fluid to allow the small particles of metal to sink, and collect at the bottom immediately. This would, probably, make some difference in the quality of the iron. We have seen that when the heated air is used for combustion, a furnace may be kept at a higher temperature than can be done by the common method, with the same expense of fuel; ergo, the expense of keeping the ore at a half smelting heat, for a long time, may be, in some measure, saved. I suspect that the chief advantage* derived at the Clyde Iron Works, by this improvement, is from keeping the furnaces a little hotter than usual; though I have not seen it stated that they were any hotter.

The air which has been used for combustion in a furnace, may be advantageously used for heating the air which is yet to be used for combustion, so as to save the fuel which is used for this purpose. I expect to see this principle applied to steam engines.† I conclude, from the best data

* The advantage here alluded to, is, that iron is smelted by heated air with three fourths the quantity of coals required when cold air is employed, and the produce of the furnace greatly increased at the same time. All the furnaces at the Clyde Iron Works are blown with it. At these furnaces the air, before it is thrown into the blast furnaces, is heated to 220° Fahrenheit, in cast-iron vessels placed on furnaces, similar to those of steam engine boilers. The Glasgow Chronicle states, that this improvement will accomplish a saving in the cost of iron smelted in Great Britain, to the amount of at least £200,000, or about $888,888, a year.

† This principle is a striking feature in the performance of the Novelty locomotive steam-carriage. By means of a bellows-sort of apparatus to force the heated air through the flue, (thus supplying a greater quantity of calorick in a given time,) an effect was obtained precisely analagous to what would result from doubling or quadrupling the size of the furnace and the extent of the flue. Nor is this all: the quantity of atmospherick air which is introduced under and through the fire, by means of a pipe, has not only the effect of forcing the heated air onwards through the flue, but is itself a source of heat—

which I can obtain, that the weight of air which is used for combustion in steam engines where coke is used, is, generally, a little more than double the weight of water converted into steam. This air may be raised to a higher temperature than the boiling point of water; but it requires only a little more than one quarter as much calorick to raise the temperature of a given weight of atmospherick air a given number of degrees, that it does to raise the temperature of an equal weight of water, in a liquid state, the same number of degrees.

U. A. B.

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equivalent to the employment of so much additional coke. It is in these two circumstances—the acceleration of the draught and the supply of fuel (if we may so speak,) derived from the atmosphere—that the great merit of "The Novelty"—the secret of its vast superiority—consists. It makes up by the quickness of its operations for the diminutiveness of its dimensions; by what it borrows from the air around it for the small supply of coke which it carries.

Neither does the rapidity with which the current of hot air passes through the flue constitute any exception to the efficiency of the process: for such is the aptitude of small circular pipes, like this, to abstract heat from any fluid conveyed through them, and to part with it again to surrounding substances, that little, if any, calorick is suffered to pass unappropriated.

The flue is made to diminish *gradually*, because the heated air cools in its passage through it, and gradually requires less and less vent. It has also a downward inclination given to it, such, that if a marble ball were dropped in at the furnace end, it would roll rapidly through all the convolutions of the pipe to the other extremity; and the object of so constructing it is, that any dust which may arise from the furnace may have always a descending passage to escape by.—(Lond. M. Magazine.)

COMMUNICATION.] [FOR THE MAGAZINE.

Mr. Editor,—In answer to a communication signed "G." in your last number, I would reply that soap is a combination of an acid with an alkali, earth, or oxide.

Fixed oils and tallow are composed of two distinct substances which are capable, by combining with oxygen, of becoming converted into two distinct acids, which, uniting with alkalies, earths, or oxides, form soap. These acids were discovered by Chevreul, and have received from him the appellations of *margarick* and *oleick*.

Common hard soap of commerce is a *margarate and oleate of soda*, mechanically combined with soda, water and resin.—Soft soap is a margarate and oleate of potassa, mechanically combined with potassa and water.

Both contain water in a state of chemical combination. X. Y. Z.

We are sorry "X. Y. Z." has not entered more generally into this subject. True, he has given the combination of the alkalies with the fatty substances, &c.; but for all that, we fear "G." will complain of its paucity. But "G." must console himself as we did; "*half a loaf is better than no bread.*"

BOSTON RAIL-ROAD MEETING.

In our last it was stated that a publick meeting had been holden in Boston on this important subject, at which certain resolutions had been reported by a committee chosen from the several wards; the consideration of these resolutions was had at a subsequent meeting, to wit: on the 2d inst. and the vote upon their acceptance taken by written ballot at a publick meeting in Faneuil Hall on the 9th inst.—the result of which, as declared by the Mayor and Aldermen was—whole number of votes given in 2498; of which were 1966 yeas, and 532 nays;—whole number of legal voters in the city is something rising 11000; but on no occasion do we recollect that ever one half of the number of voters in the city have appeared at the polls.—In the present case it will be seen that less than one half of the latter proportion have been induced to signify their wish *pro* or *con* on the questions submitted to them. We believe that the great majority of our citizens are of opinion that the commonwealth should take the lead in this great enterprize, and under the influence of this impression is the result of this meeting to be accounted for.

CLAXTON'S DECIMAL TABLES.

We would invite the attention of the practical mechanick to these tables. They afford a *short cut* to many difficult questions, which, to be obtained in the old method, require a long concatenation of figures, and a considerable time to work them, and after all no certainty of its being correct, at least, till it be proved so; whereas, with these tables, in a few moments, a person will find a correct answer to almost

any of the numerous questions arising in the course of business.

Forty-eight tables are printed on a fools cap sheet, accompanied by a small pamphlet, explanatory of the manner of using the tables; an explanation of arithmetical Signs and Terms; the method of working Decimal Fractions; a Numeration Table; examples in Addition, Subtraction, Multiplication, Division, and Reduction of Decimals; with a Table and Scale for reducing Vulgar to Decimal Fractions. These tables embrace, among other subjects, the following, viz: Mensuration of Superfices and Solids; Weighing of Metals and other Bodies; Pressure of Fluids; Reduction of Coins, Weights, and Measures. The author, in his introduction, says:

"This little work is intended for the practical man; it combines expedition with accuracy, not being liable to those errors inseparable from hasty calculations. It was thought best to have the tables on a separate sheet, to be hung up in a counting room or workshop. When the tables become familiar it will not be often necessary to refer to the explanatory pamphlet. If an extra sheet of tables be procured, it may be cut up, and those tables most wanted may be put into a pocket book for reference at any time or place.

It is not intended to interfere with the present method of teaching arithmetick, but rather to increase the taste for that subject, and geometry; such knowledge being necessary to the successful practice of the mechanick arts.

It is seven years since these tables were commenced, specimens of them have been put into the hands of persons who were thought capable of judging of their merits, several of whom have expressed a wish to see them published, and it is from a desire to advance the standard of this kind of knowledge among mechanicks that they are offered to the publick. The tables consist of nine lines only, the figures may be extended on each side of the decimal point, or index, at pleasure, although twelve figures in a line will be sufficient, and will contain answers to all the round or simple numbers, from one millionth part of a unit to nine millions of units; by adding two or more of these together, the answers to all the numbers within that range may be obtained.

As brevity is a leading feature of this work, only such rules and examples are given, as were thought necessary to explain the nature and uses of the tables.

The key table will assist the learner in finding the indexes, they being always in the same relative situation in all the tables.

These tables appear to be in their simplest form; the answers to nine numbers, are made to answer all others, whether above or below unity, merely by shifting the decimal point, thereby avoiding many repetitions, and lessening the liability to error."

By the assistance which the explanations afford, and a little practice, mechanicks may soon become acquainted with this short and simple method of working many things which occur in the business of the practical man, but which are often neglected for want of a ready method to do them.

At a stated monthly meeting of the Franklin Institute, held at their hall, in Philadelphia, on Thursday evening, May 27, the following letter, addressed to the chairman of a committee appointed "to try experiments on water wheels," was read:

Boston, May 6, 1830.

Sir,—The laudable measures adopted by the Franklin Institute, for ascertaining "the value of water as a moving power, and the relative effects produced by it on water wheels of different constructions," having being made known to the directors of the New-England Society for the Promotion of Manufactures and the Mechanick Arts, the undersigned were appointed a committee, to make inquiry, as to the expediency of affording aid in the prosecution of such experiments as may be necessary to establish the principles upon which that power may be calculated, and most advantageously applied.

From information derived from the various communications published in the Journal of the Franklin Institute on this subject, and that obtained by one of the committee, who has recently visited Philadelphia, and examined the apparatus used in the experiments, we are happy to assure you of our entire confidence in the abilities of the gentlemen charged with this highly interesting and important inquiry, and of our satisfaction as to the manner in which it is prosecuted. The results cannot fail to be of

great publick utility, and to do honor to the institution which caused them to be attained. We, therefore, are authorized by the New-England Society for the Promotion of Manufactures and the Mechanick Arts, to subscribe three hundred dollars to the fund required for conducting the experiments, which have been commenced under such favorable auspices, and enclose, most cheerfully, a draft for that amount.

With great respect, we have the honor to be

Your most obedient servants,

P. T. Jackson, H. A. S. Dearborn, *Committee, New England Soc.'y P. M. and M. A.*

Saml. V. Merrick, Esq. *Chair. Com. Experiments, &c. &c. &c. of the Franklin Institute.*

On the Formation of Steel by means of Silica.—It is well known to chemists, that silicum combines freely with iron, and also, that certain persons have considered silica a substance which possesses in common with carbon, and perhaps boron, the power of converting iron into steel. M. Boussangault, if we mistake not, put forth some views, in which he considered silicon as the constant agent in the production of steel.

The Editor of the *Recueil Industriel* has described several cases, in which the presence of silicon appears to have an important influence of this kind. Some time since, Dr. Eynard of Lyons, having put some files into a mixture of five parts of water with one of sulphurick acid, was astonished when he took them out, to find, at the bottom of the glass vessel in which they had been placed, a grayish white and glairy substance. This, being collected and dried, proved to be silica.

In 1732, MM. Perru of Neufchatel established a manufactory of steel cylinders at Lyons. These cylinders, which were highly polished, and so hard as to be untouched by the file, had been fused, it is said, with *silica*. They have never been imitated. A pair of these cylinders, 5 inches in diameter, sell at this time for 2400 francs.

Some years since, a person of the name of Ranquet, of Lyons, formed vessels of white cast iron of extreme hardness. M. Culhot manufactured cylinders from the fragments of these vessels, and the cylinders were of such hardness, it was impossible to shape them by cutting instruments, so that they could be worked only by emery, and similar substances, occupying months for the purpose. This person made a secret of his process, but it is said, used no charcoal in his process.

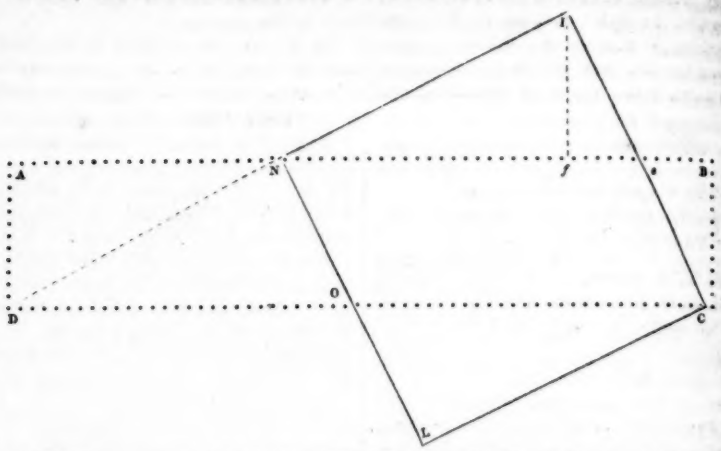
M. Eynard found silica in cast iron, but not in forged iron; its occurrence in the former, or rather the presence of silicon, is a well known circumstance.

Upon these facts, the Editor founds some earnest recommendations to those who have the opportunity of ascertaining whether the cementation of iron without charcoal, but with silica alone, would produce steel, and in what proportions the silica ought to be mixed, to obtain a very perfect and hard steel; there are also other points urged, which are either already upon the minds of metallurgists, or are naturally suggested by the two above.—(New Edinburgh Philosophical Journal.)

Easy way of breaking Glass in any direction.—"Dip a piece of worsted thread into spirits of turpentine, and put it round the glass in the direction you require it to be broken, then set fire to the thread, and the glass will break in the direction of the thread, or apply a red hot small wire round the glass, and if it does not crack immediately, throw cold water on it, and the desired effect will be accomplished. This is a very useful method for chemists, for broken glasses may, by this means, be rendered serviceable to the labratory. The explanation of this is as follows:—By the application of heat to glass, as to other bodies, the part heated expands; and as glass transmits heat but slowly, the parts to which heat is applied, expand faster than the other parts, and thus separate from them, or the glass cracks. In domestick economy, a knowledge of the simple fact is of considerable importance."

The German Silver, which is now coming into vogue, has been introduced, as its name denotes, by the Germans into Europe, but is nothing more than the white copper long known in China. The Goldsmiths Company of London have thought it proper to warn the publick by advertisements in all the newspapers that it does not contain a single particle of real silver. This is true, for it is only an alloy of copper, nickel, and zinc; but it would have done no discredit to their candor to add, that it is, on account of its perfect unalterability, superior for many purposes (such as musical instruments, touch-holes of guns, &c.) to either silver or gold. Although only now coming into *known* use in England, it has been no stranger to the manufactories of Birmingham for at least thirty years and more.

ANSWER TO MATHEMATICAL QUESTION No. 2. AT P. 160.*



Let A B C D represent the plank. From B, set off B N = 6 feet, and B e = 1 foot. Also, from C, set off C O = 5 feet. Draw the line C e, N O, and N D. If the plank be divided according to these lines the parts may be so arranged as to form a square. Place the triangle, B C e, so that B e shall coincide with $e f$, and the triangle, N A D, so that N A shall coincide with N f; also the triangle, N D O, so that D O shall coincide with C O, and the square will be formed. As the area of the plank = $10 \times 2 = 20$ square feet, the side of the square will then be equal to $\sqrt{20} = 4{\cdot}47213+$. T. W. P.

* We have received two solutions of this question; the above is the best, there being one cut less than in that of our correspondent T. C.

Amount of Money expended in each State and Territory, by the United States, upon Works of Internal Improvement, from the adoption of the Federal Constitution to the 1st Day of October, 1828.—(Gray & Bowen's American Almanac, for 1830.....Boston.)

Maine,	$11,724 22	Tennessee,	4,200 00
Massachusetts,	104,042 46	Ohio,	390,159 03
Connecticut,	2,069 97	Indiana,	108,623 88
Rhode-Island,	195 19	Mississippi,	49,385 32
New-York,	68,138 45	Illinois,	8,000 00
Pennsylvania,	39,728 32	Alabama,	81,762 78
Delaware,	307,104 01	Missouri,	22,702 24
Maryland,	10,000 00	Arkansas,	44,690 00
Virginia,	150,000 00	Michigan,	48,607 95
North Carolina,	1,000 00	Florida,	799,002 01
Kentucky,	90,000 00	Total	$2,341,136 03

Road from Cumberland to the Ohio,	1,662,246 75
Continuation of the Cumberland Road,	453,547 86
Repairs of the Cumberland Road,	55,510 00
Road from Nashville to Natchez,	8,000 00
Road from Wheeling to the Mississippi river,	10,000 00
Road from Missouri to New Mexico,	30,000 00
Road from Mississippi to the State of Ohio,	5,539 35
Road from Georgia to New Orleans,	5,500 00
Roads in Tennessee, Louisiana, and Georgia,	15,000 00
Road from Nashville to New Orleans,	7,920 00
Surveys of Roads and Canals,	166,681 49
Surveys of Maps and Charts of the Ohio and Mississippi rivers,	4,185 24

Improving the Navigation of the Ohio and Mississippi rivers,	103,409 72
Military Roads,	10,218 43
Surveys of the water courses of the Mississippi river,	11,122 04
Road through the Creek Nation,	3,621 01
Opening the old Natchez road,	5,000 00
Breakwater at the mouth of Delaware Bay,	5,000 00
Grand Total	$4,903,637 92

"*On the use of chilled Cast Iron, for Punches, and other Tools.*—It is well known, that in making holes in red hot iron articles, such for instance as wheel tire, horse shoes, &c. the hardened and tempered steel punches become softened from the effect of the heat; and changing their shape, must be repaired from time to time.

Mr. Peter Keir, engineer, of St. Pancras, several years since, having occasion to make many nail holes, in the wheel tire of artillery carriages, and horse shoes; and having experienced the above inconvenience in a very great degree, luckily thought of substituting punches made of chilled cast iron, for those of steel, and which he found fully to answer the purpose, as they constantly retained their original hardness, notwithstanding they very frequently become red hot in using.

As, however, chilled cast iron is not sufficiently tough to bear bending, without breaking, he found it necessary to strengthen his punches, by surrounding and inclosing their stems in cast iron holes, made of shapes corresponding with the stems, in properly shaped supports, and having their points only standing out a sufficient length for use."

"*On forming Cutting Tools of Cast Steel, as hard and tough as possible.*—It is well known, that the proper hardening heat for cast steel, is exceedingly difficult to be attained, and that a very little excess of heat is sufficient to deprive it of its most valuable properties; hence in order to obtain edges or points of steel instruments, of the greatest degree of strength for important purposes, such, for instance, as the edge of knives for dividing mathematical instruments, Mr. Stancliffe, an excellent maker of those instruments, and formerly a workman of the late celebrated Mr. Ramsden's, adopted the following method:

After shaping the tool, and condensing it by hammering, he carefully heated the point, and quenched it: he then, with the edge of a file, made trial, by filing along from the soft and unhardened part, to that part of it, where it became hard; and formed his cutting part, or edge, by grinding and whetting that part to shape. He was thus assured of the quality of the tool, being the best that the steel he employed could possibly produce; nor did it require tempering as usual.

It is to be hoped, that this valuable process will be adopted, wherever tools, possessing all the advantage, in point of hardness and strength, which steel can give them, are required."

Instructions for Lackering and re-Lackering Brass.—Old brass work that is much pitted must be turned again in the lathe. When it is black and greasy, such as a drawer handle, it should be put into a boiling solution of common soda or potash, with a small lump of quick lime, then taken out, and after being washed in water, dipped into a pickle until it is clean; which pickle is made by adding 1 lb. of the best nitrick acid to ½lb. of sulphurick acid, and diluting the mixture with water till on putting a piece of brass into the mixture it will turn white without any bubbling or effervescence. Greasy brass work put into this pickle would be only partially acted upon, if not previously put into the first solution. When your brass is clean, wash it in two different waters, roll it in saw dust till dry, brush the saw dust off, and burnish with a steel burnisher and ale grounds or small beer. Then throw it into water till you are ready for lackering; but observe that it ought to be lackered as soon as possible, because the air soon tarnishes it. The brass work should be heated to about 212 degrees. The lackering cup should have a thin brass wire fastened over the top to stroke your brush on, that there may not be too much lacker in it; when there is an excess of lacker, the heat thins, and spreads it on the surface; it dries in lumps, and is not uniform.

For the lacker.—Take twenty ounces of alcohol, 1½ dram of turmerick root in powder, and 2 grains of hay saffron, put them together and let them stand 24 hours in a warm place; pour off the clear tincture, and add gamboge ¾ ounce, gum juniper ½ ounce, gum mastick ½ ounce, seed lac ¾ ounce, powdered glass 4 ounces (the glass serves

to separate the gums,) till they are dissolved. Shake them well together every day till dissolved, then add 3 drams of dragon's blood. The lacker will then be of a deep yellow, such as is used for philosophical instruments.

Take 32 ounces of oil of turpentine, infuse in separate portions of it, 4 ounces of gamboge, 4 ounces of dragon's blood, and 1 ounce of anatto, and let them stand in a warm place till the solutions are completed. By adding a little of one or other of these three solutions to your lacker in the cup, you may have it of any tone of color required, from the lightest straw to a deep gold color.—Lond. Mech. Magazine.)

Tin Lacker.—Take 8 oz. of amber, 2 oz. of gum lac, melt them in separate vessels, and mix them well together; then add half a pound of drying linseed oil. Into a pint phial put half a pint of spirits of turpentine, and digest in it a little saffron; when the color is extracted, strain the liquor, and add gum tragacanth and anatto, finely powdered, and in small quantities at a time, till the required tone of color is produced; then mix this coloring matter with the first compound before prescribed, and shake them well together till a perfect union takes place. If this varnish be laid over silver leaf or tinfoil, it will be difficult to distinguish it by the eye from gold. It is by a varnish of this kind that leather, paper, or wood, covered with silver leaf, is made to appear as if it were gilded. The lacker is also applicable to tin plate articles, but small articles of finely polished brass are usually coated with a thiner composition.—(Ibid.)

Method of procuring good Yeast.—"Put four or five handfuls of hops in a linen bag, place it in a large pot, and pour on it boiling water, or make it boil for some time. Divide the decoction into equal parts. The first half is poured while hot into a kneading trough in which is a little sour paste or dough. Add to it a little sugar, a few whites of eggs well beaten, and a sufficient quantity of wheat flour to form a paste of ordinary consistency. Knead it well and cover it over. When the mass is well risen, it may be used for the purpose of fermenting the finest wheat paste or dough, without any fear that the bread, after baking, will retain the least sourness, because the acetick acid of the leaven has been completely decomposed in the course of the fermentation. It is probable that this would not have been the case without the sugar and the eggs. To obtain a leaven which will answer for future batches, reserve a portion of the dough, pour on it the second half of the decoction of hops, previously heated, and add the same quantity of sugar, white of eggs, and flour as before; knead the whole with a bit of the former leaven and let it rise in the trough. Nothing but flour need afterwards be added."

The Automaton Chess Player.—Baron Von Kempelen, the inventor of this *androides* was a native of Presburg, in Hungary, and a Member of the Aulick Council of the German Empire. He was a man of considerable attainments, not only as a mechanician, but in general literature. The determination to make this machine originated in the surprize excited in the Court of the Empress Maria Theresa by the performances of an eminent juggler. Von Kempelen had been invited to Court to witness this exhibition; and after the performance, declared that he would produce something which would surpass any thing they had seen, and in due time he completed his chess player. In 1769, it was exhibited in various parts of Germany; it was afterwards taken to Paris; and in 1783, was first shown in London. After a tour through England, Kempelen ceased exhibiting his figure. It has been stated that his reason for this was that being a man of fortune and station, he was unwilling to continue in this business. Another reason, however, was given by the late Mrs. Rivardi to a gentleman well known in this city [Philadelphia.] She stated that she was well acquainted with Kempelen and his family; that his daughter, a girl of twelve years of age, and an excellent chess player, was his coadjutor; and that her health declining from the confinement (within the machine) to which she was subjected, it became necessary to stop the exhibition. Von Kempelen, who has now been dead above twenty years, repeatedly offered his machine to M. Maelzel, (by whom the exhibition of it has been lately revived,) but demanded 20,000 francs for it, which was thought too much, and the bargain was consequently not made. About two years after the death of Kempelen, his son renewed the offer, and proposed to take one half of the sum demanded by his father, to which M. Maelzel agreed, and the figure was removed from the garret where it had lain for about twenty years.—(*Franklin Journal.*)

The account given by Mrs. Rivardi confirms the conclusion come to by all the writers who have ever treated of this extraordinary piece of mechanism, namely, that the moves must be made by some person concealed within it through the intervention of machinery operating on the principle of the pentagraph.